STAKEHOLDER REVIEW DRAFT

DAGUERRE POINT DAM
FISH PASSAGE IMPROVEMENT PROJECT
2002 FISHERIES STUDIES

Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam

Prepared for:

CALIFORNIA DEPARTMENT OF WATER RESOURCES
Division of Planning and Local Assistance
Integrated Storage and Investigations
Fish Passage Improvement Program
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March 7, 2003

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1 1.0 Introduction

1.1 GENERAL

The potential for improved fish passage at Daguerre Point Dam to provide benefits to salmonids is an important issue in both the analysis of the need for the proposed project and the analysis of various project alternatives. Passage in and of itself is not inherently beneficial, and the method used to provide for improved passage may affect the relative benefits to salmonids. The extent to which fall-run chinook salmon, steelhead (federal-listed threatened) and spring-run chinook salmon (federal-listed threatened/state-listed threatened) may benefit from the project needs to be evaluated and weighed by decision makers against the costs and impacts of the various project alternatives. The analysis of potential benefits from improved fish passage is also necessary in order to determine whether documented functional problems associated with the existing dam and fish ladders are having significant impacts on salmonids.

1.2 HYPOTHESES REGARDING THE MECHANISMS BY WHICH DAGUERRE POINT DAM MAY AFFECT SALMONIDS

This analysis has been focused on the various hypotheses regarding the effects of Daguerre Point Dam on salmonids. These hypotheses include.

- The dam, with the existing fish ladders, blocks or substantially delays upstream passage of salmonids during their spawning migration, resulting in underutilization of upstream habitats.

There is agreement that the existing fish ladders at the north and south abutments of Daguerre Point Dam are less than optimal in design and function. Their dysfunctional nature can best be described from the point of view of a fish moving upstream to spawn. Fish migrating to spawn approach the dam via a riffle located about 100 feet from the north abutment, and then enter a wide and deep pool at the base of the 575-foot wide dam. The dam's ogee-shaped cross section provides for sheet flow over the crest of the dam. The concrete apron at the base of the dam extends downstream for about 20 feet, and the substrate then slowly grades towards the surface for about 40 to 60 feet. Except in the area immediately upstream of the riffle, flow velocities in the pool area are low and there are eddying currents under low to moderate flow conditions. The entrances to the fish ladders have a cross section that represents only a small fraction of the cross-sectional area available for flows across the face of the dam at virtually all flow levels. As a result, flow through the fish ladders is a small percentage of flow over the dam face. Fish entering the pool via the riffle need to pass only a few yards upstream to be beyond the entry point for either fish ladder, and the high volume of flow over the dam relative to discharge from the fish ladders means that the primary flow cue for migrating salmon is provided by flow over the dam. As a result, large numbers of migrating salmon are often observed holding in the pool at the base of the dam.

Carcass counts and observation from 1953 to 2002 indicate many salmonids reaching the dam eventually find the fish ladders and utilize them; fall-run chinook salmon are observed using the ladder throughout the fall and spawning upstream of the dam. However, spring-run chinook salmon and steelhead migrate upstream during winter and spring, when flows are generally higher. Under these higher-flow conditions, the ladders pose a number of problems. Moderate to high flow over the dam overwhelms flow from the ladders entrances, making it more difficult for fish to detect the already weak flow cue from the ladders, resulting in delayed migrations. Second, under moderate to high flow, the ladders have been observed to create standing waves within various ladder compartments, effectively blocking passage in the ladder. The ability of spring-run chinook salmon and steelhead to utilize the ladders for passage may thus be impaired.

- During passage delay, adults may experience losses in condition due to temperature and injury. This may affect spawning success.

Short-term delays in spawning migration are not inherently problematic; salmon and steelhead health and/or egg viability may not be adversely affected by them. There is concern, however, that water temperatures in the pool below the dam may be higher than optimum for all salmonids during the warmer parts of the year, especially during low-flow conditions in late summer, and that temperature effects may adversely impact egg viability. In addition, the face of the dam is rough and fish attempting to jump over the face of the dam may be injured (descaled) in the attempt. Prolonged delay at the dam, combined with continued exposure to higher-than-optimal temperatures and the potential for injury, raise concerns about disease and subsequent effects on spawning success.

- The large plunge pool at the base of the dam allows predatory fish to concentrate and prey effectively on emigrating juvenile salmonids.

There are widely expressed concerns about predation in the plunge pool at the base of the dam, where juveniles passing over the face of the dam would be disoriented and especially vulnerable to predation in the deep, low-velocity water. Predators hypothesized to be concentrating in this area include Sacramento pikeminnow (*Ptychocheilus grandis*), striped bass (*Morone saxatilis*), smallmouth bass (*Micropterus dolomieu*), and American shad (*Alosa sapidissima*).

- If emigrating salmon and steelhead juveniles encounter high water temperatures in the reach below Daguerre Point Dam, they cannot return to the lower-temperature habitat upstream because their passage is blocked by the dam and difficulty finding ladder entrances.

Although fall-run and spring-run chinook salmon and steelhead juveniles have generally emigrated from the Lower Yuba River before water temperatures rise in the summer, in years of low flow and high temperature there is concern that juveniles may encounter high water temperatures at the confluence with the Feather River in May and June. And steelhead, which may rear year-round, would likely encounter such temperatures at least once every 5 to 7 years (which is the normal recurrence interval for drought and associated low flow conditions in northern California). While there is no evidence that emigrating juveniles actually behave in this manner, the concern is that these juveniles would not be able to return to cooler water habitat upstream because they could not pass the ladders at Daguerre Point Dam.

- The dam alters sediment erosion, transport, and deposition regimes in the river, both upstream and downstream, and affects the amount and quality of spawning habitats.

One function of Daguerre Point Dam was to capture sediment and therefore help reduce flooding potential downstream near the confluence of the Feather and Yuba Rivers and on the Sacramento River. It performed this function well for a very short period of time in its early history and has since filled to capacity with gravels. According to local flood control officials, the sediments behind the dam are mobilized during very high flows, and the dam re-fills with sediment as high flows begin to decline. During flooding, this would generate a pulse of sediment to the downstream reaches, followed by settlement of suspended sediments behind the dam. The finer components of the sediments moving during floods would settle out behind the dam. After a scouring flood flow, the dam thus effectively traps finer components of the suspended sediment behind the dam. The downstream area may receive fewer of these finer elements of suspended sediment than it would if the dam were not in place. In addition, the dam affects the quality of habitat immediately downstream of the dam; the energy of flows over the dam is dissipated by the plunge pool at the base of the dam, and flow velocities immediately downstream of this pool are probably lower than they would be if the dam were not present. The large, wide, cobble plug that forms the downstream edge of the plunge pool is evidence that flows in this area often lack the velocity to flush larger sediments downstream.

1.3 PURPOSE AND SCOPE OF THIS REPORT

The purpose of this report is to examine available data on habitat conditions, flow, passage and spawning above and below Daguerre Point Dam to address these aforementioned hypotheses. Based on this review, the report then analyzes the potential benefits or impacts of improved passage at the dam. These benefits/impacts depend on factors directly related to passage and to the indirect effects of various alternatives on both passage and habitat conditions in the Lower Yuba River. The analysis of these factors is based on a review of available data from CDFG, USFWS, Jones & Stokes Associates, Inc. (JSA), and other sources. It also incorporates recent field observations of river habitat conditions made by ENTRIX, Inc. (ENTRIX) in September of 2002. It addresses the following questions:

- How much potentially suitable spawning habitat is available in the Lower Yuba River?
- What is the current level of habitat utilization by salmonids of the Yuba River?
- To what extent would improved passage at Daguerre Point Dam affect spawning and rearing of the three salmonid populations of interest?
- How would the various alternatives for passage affect spawning and rearing or change impacts to various salmonid life stages?
- To what extent might factors other than passage affect the net benefits from passage improvement in general, and from the various alternative methods for enhancing passage improvement?
- What, if any, changes in flow management in the Lower Yuba River would be needed to address concerns about potential delay in emigration and associated exposure of juveniles to adverse temperature and predation during emigration with any alternative that include keeping the dam structure in place? Are these effects ameliorated by any of the proposed passage alternatives?

In answering these questions, the report focuses on data related to the hypotheses regarding the mechanisms by which Daguerre Point Dam may affect salmonids.

1.4 Data Limitations

Data on fall-run chinook salmon spawning escapement are available from annual carcass surveys conducted from 1971 through 1989 by CDFG (Mills and Fisher 1994) and Jones and Stokes from 1990 through 2001 (JSA 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, and 2001). There are preliminary data from Jones and Stokes (2002). In addition, there are redd counts available from the years 2000, 2001, and 2002. CDFG (1991) also prepared a *Lower Yuba River Fisheries Management Plan*, which also contains data on habitat type and availability throughout the Lower Yuba River, the composition of the aquatic community, and flow/temperature/habitat relationships. Much of this report is based on 1987-88 field surveys performed by Beak Consultants. CDFG (1991) also developed a temperature/flow model for the system, based on data from USGS gauging stations immediately downstream from Englebright Dam and at Marysville.

The available data have some limitations:

- Carcass counts were not conducted in the Rose Bar (upstream) reach of the Lower Yuba River in 15 of the 23 years between 1971 and 1994, and were not reported by reach during 1976 and 1990. In 9 of the 23 years for which no carcass surveys were conducted in the Rose Bar Reach, CDFG assumed that 15.5% of spawning occurred in this reach. In another 6 years, CDFG did not make this assumption and reported no counts. The assumed 15.5% percentage of spawning in the Rose Bar reach is about 50% of the spawning in this reach observed by JSA (2001) during the period 1994 through 2001. Because it is not valid to apply statistical methods to data sets for which a constant has been applied, the ability to track trends in spawning escapement, by reach, is limited to the period 1994-2002. Finally, pre-1991 carcass counts did not report data by adult and grilse, making it impossible to determine the total number of spawning adults in the escapement.

- Although there have been redd surveys in 1998 and 2000-2002, the methodology and timing of these surveys has not been consistent, nor have the surveys covered the entire spawning period. CDFG redd surveys in 2000 were conducted weekly for the month of September, using kayaks. USFWS redd surveys in 2001 involved one-time surveys of each reach, and included a one-day, one-reach September 21 survey for spring-run chinook salmon redds and a series of surveys for fall-run chinook salmon redds from November 13 to December 4. Redd surveys conducted by JSA for Yuba County Water Agency in 2000 involved one-time surveys of three reaches (Rose Bar, 7 October; Parks Bar, 18 October; and Daguerre, 27 October. USFWS surveys of steelhead redds in 2002 covered three reaches above Daguerre Point Dam in early April and were repeated in early September. These surveys do not provide a long-term or consistent data base that might be used to track trends or to draw relationships between the number of redds and escapement; the redd data are a snapshot of spawning under conditions which may or may not represent behavior under different sets of hydrologic conditions. Because redd surveys have not covered the entire spawning period, it is also probable that the total number of redds has been underestimated and that redd superimposition has also been underestimated. The redd survey data are useful, however, for examining the relative use of various spawning habitats (by reach and by location of redds within reaches).

- There is only essentially anecdotal data regarding steelhead spawning in the Lower Yuba River and/or its tributaries. No consistent surveys of steelhead spawning redds have been conducted; this is probably because steelhead spawning occurs when survey conditions would be relatively difficult.

- There has been no systematic program to mark juvenile salmonids in the Lower Yuba River. As a result, it is not possible to analyze possible relationships between juvenile abundance and subsequent adult escapement. Stock-recruitment relationships cannot be established. It is also not possible to examine juvenile use of habitats and juvenile survival during emigration.

- In addition, there has been only one (1987-88) survey of fish distribution in the Lower Yuba River (CDFG 1991). In February and May of 1987, CDFG conducted electrofishing surveys, but these were limited to areas with a depth of $\geq$ 1.5 feet due to boat access limitations. Snorkel surveys were conducted in May of

1988. These surveys, while they provide some useful baseline data, were conducted during two of the driest years on record at the beginning of a 6-year drought period. They may therefore not accurately represent the fish community during other water-year types.

These data limitations often made it difficult for a direct analysis of potential benefits from improved fish passage. It was not, for example, possible to develop a quantitative index of redd superimposition by reach. Faced with such limitations, the various hypotheses about fish passage and its potential effects on salmonid spawning migration, spawning success, rearing, and juvenile rearing and emigration were addressed inferentially. For example, the potential for significant redd superimposition was evaluated by comparing the estimated number of adult spawners in the total escapement to the number of redds counted. A very high ratio of spawners to redds would be an indication of high potential for redd superimposition; a low ratio would suggest less redd superimposition.

Such inferential analysis allows some indirect testing of the various hypotheses, providing insight into the probable validity of the hypothesis. For example, it is possible to gain some insight into the potential for high rates of predation on emigrating juveniles by examining water temperatures. Since we know that warm water predators such as small mouth bass do not feed actively at temperatures of less that about 60° F, it is possible to infer the relative potential for predation by such fish from temperature data. Similarly, it is possible to draw reasonably valid inferences about potential for predation by striped bass from a comparison of their habitat requirements and the habitat conditions in the Lower Yuba River.

Taking such an inferential approach allows us to test the various hypotheses regarding fish passage and the impacts of Daguerre Point Dam on spawning and rearing success of salmonids, and to draw qualitative conclusions about the relative benefits of the proposed alternatives for improving fish passage. However, precise predictions of salmonid response to potential changes in fish passage, spawning, and rearing are not feasible.

2 2.0 Potential Available Spawning Habitat and Utilization

2.1 YUBA RIVER WATERSHED

The Yuba River is a tributary of the Feather River, with a drainage area of 1,339 square miles. A majority of the drainage is controlled by several large reservoirs (Figure 2.1). New Bullards Bar Reservoir, located about 20 miles upstream of the study area, controls the North Yuba River and several major tributaries. Englebright Reservoir, the upstream limit of the study area, captures flow from the North, Middle and South forks of the Yuba River. There are numerous minor reservoirs, primarily for power generation, upstream of these two major facilities.

The Lower Yuba River extends from the confluence of the Yuba River and the Feather River at Marysville upstream for approximately 24 miles to Englebright Dam. In this reach, it is joined by three tributaries, Sanford Creek, Deer Creek and Dry Creek, the latter two of which are also controlled by reservoirs (Deer Creek Reservoir and Merle Collins Reservoir, respectively). All three tributaries join the river upstream of Daguerre Point Dam.

2.2 LOWER YUBA RIVER REACHES

California Department of Fish and Game (CDFG 1991) provides maps (but does not indicate river mile) of four reaches of the Lower Yuba River (Figure 2.2):

- The Narrows Reach, beginning at Englebright Dam and extending downstream to just upstream of Rose Bar;
- The Garcia Gravel Pit Reach, extending downstream to Daguerre Point Dam;
- The Daguerre Point Dam Reach, extending downstream to Marysville; and
- The Simpson Lane Reach, encompassing the channel as it passes through Marysville to the confluence with the Feather River.

For purposes of evaluating salmonid spawning and related issues, both CDFG and JSA (2001) have also often divided the Lower Yuba River into three different reaches (Figure 2.3). These do not correspond to the reaches used by CDFG in its 1991 Management Plan:

- The Rose Bar Reach: Englebright Dam to Parks Bar (just upstream of Highway 20; 3.99 miles);
- The Parks Bar Reach: Parks Bar to Daguerre Point Dam (6.34 miles); and
- The Daguerre Reach: Daguerre Point Dam to Marysville (6.8 miles)

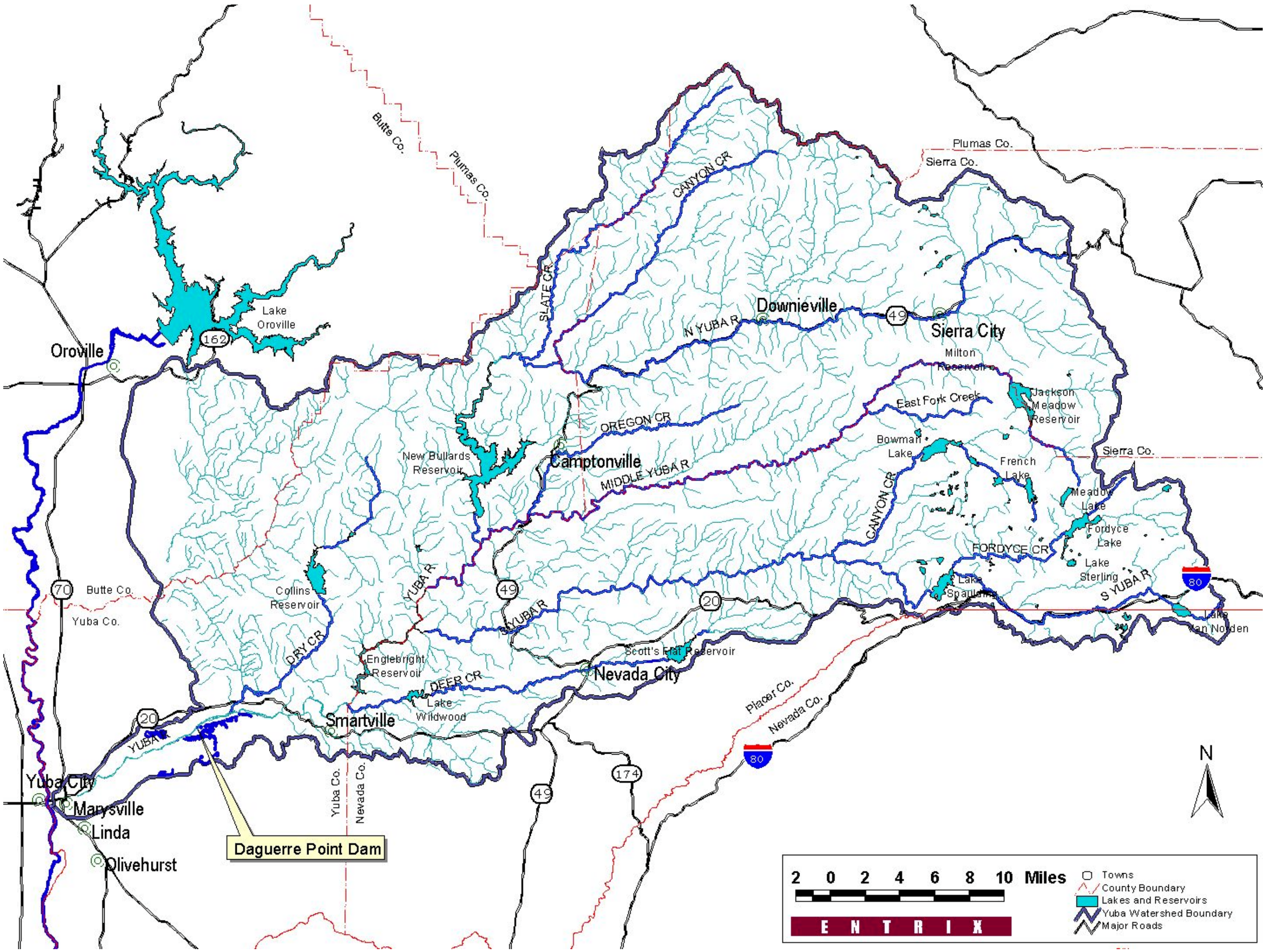

Figure 2.1 Yuba River Drainage

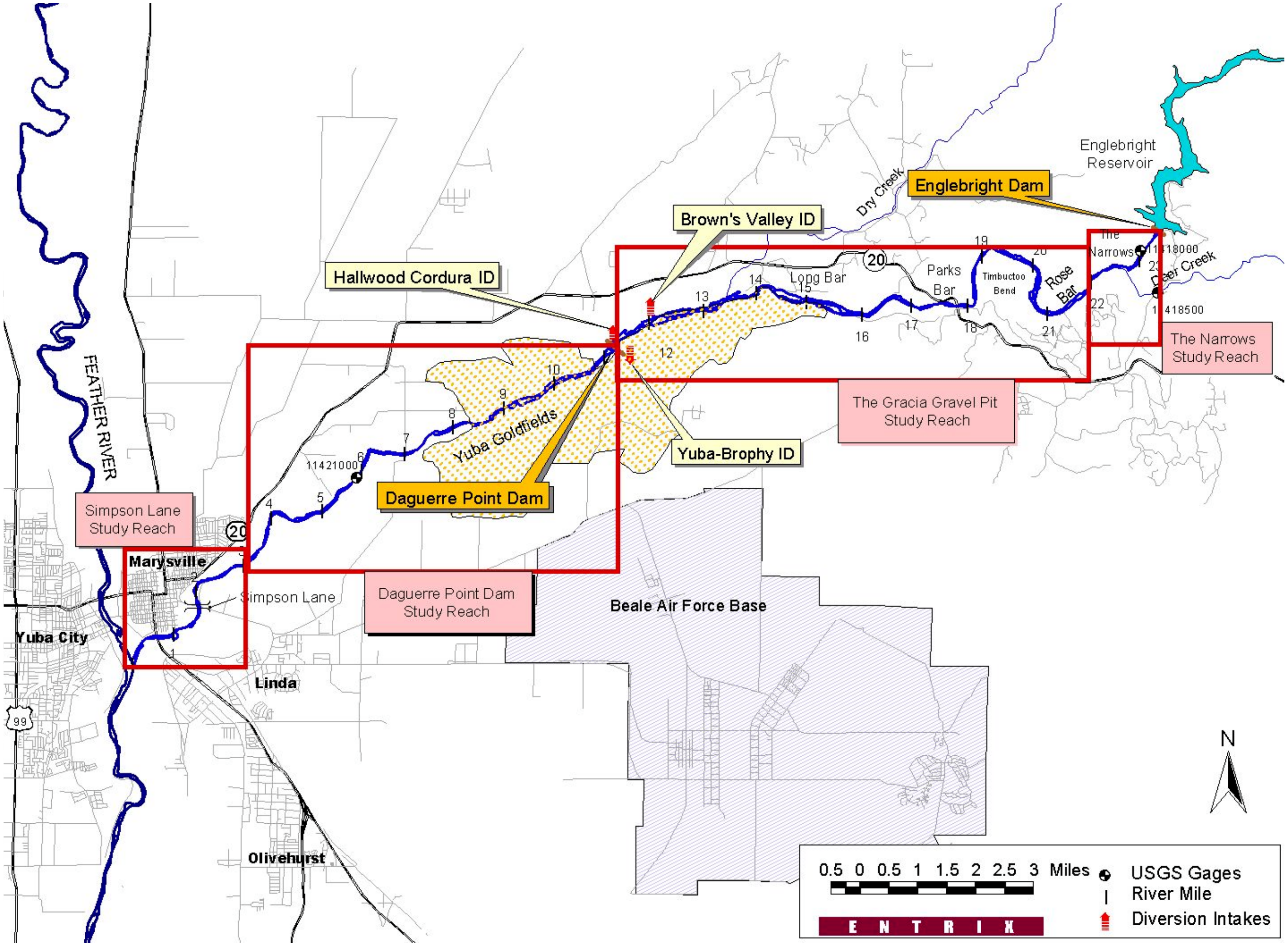

Figure 2.2 **Lower Yuba River, from Englebright Dam to Marysville Showing Four Study Reaches Used as the basis for the CDFG 1991 Lower Yuba River fisheries Management Plan**

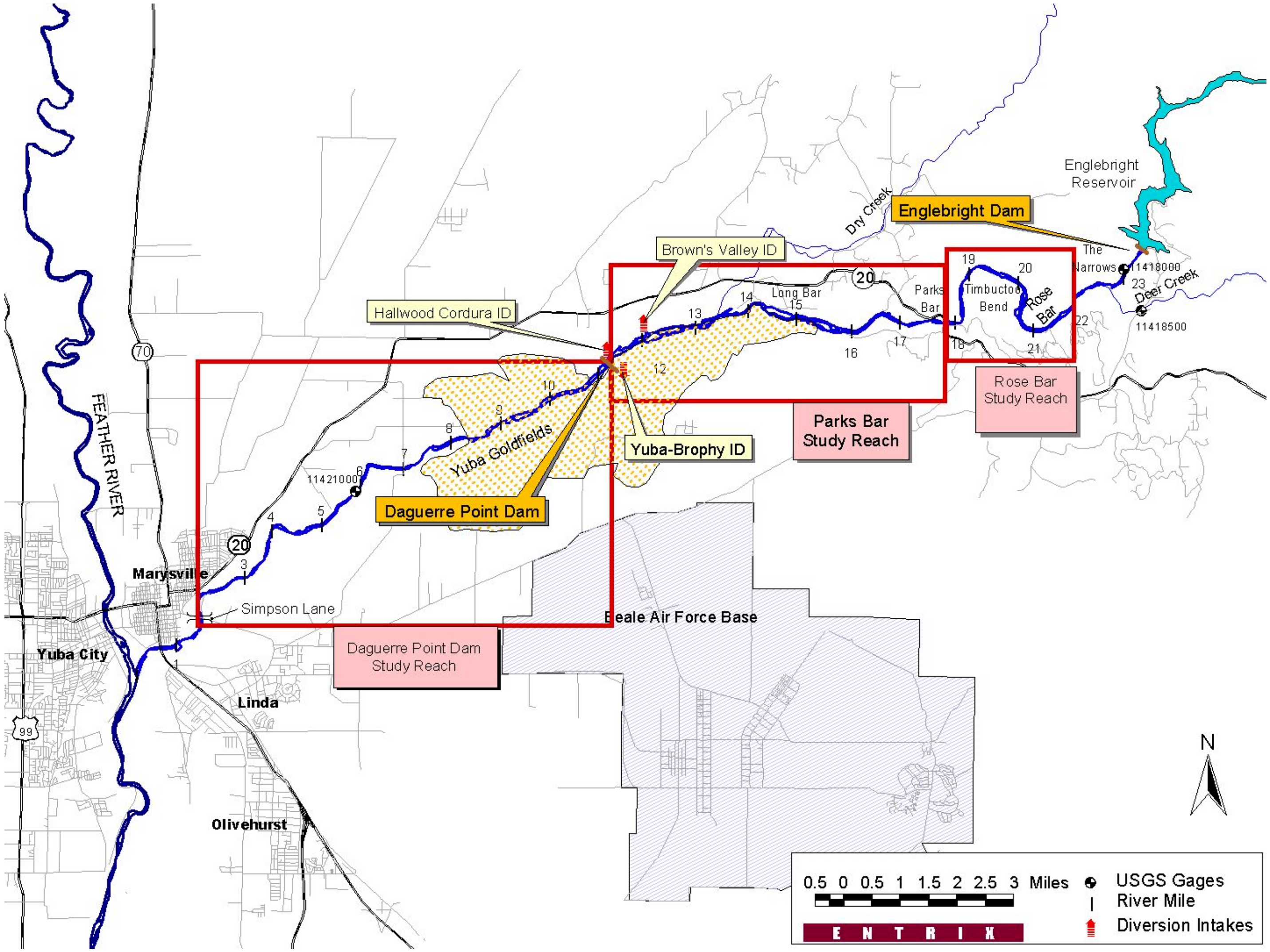

Figure 2.3 Lower Yuba River, from Englebright Dam to Marysville Showing Three Study Reaches used as the Basis for 1971 to 2001 Escapement Studies and Used in this Report for Evaluation of Benefits from Improved passage at Daguerre Point Dam

For purposes of this report, the JSA (2001) reaches have been used as the basis for analysis, primarily because these reach definitions clearly distinguish habitats upstream of Daguerre Point Dam from those below the dam. The CDFG (1991) reaches were not used in this study because the CDFG Garcia Gravel Pit Reach encompasses distinctly different habitat conditions.

2.3 RIVER CHANNEL GEOMORPHOLOGY - OVERVIEW

The descriptions of geomorphological conditions in the Lower Yuba River have been based on recent field observations. In general, the conditions in any given reach will remain similar from year to year. For example, the ratio of total riffle length to total run/glide length within a reach (CDFG 1991) is likely to remain relatively constant over time. However, local conditions, such as the position and configuration of a given riffle-run complex may change from year to year in response to flow events. Precise location of river features is therefore not useful or appropriate, because these features may "migrate" upstream or from one side of the river to another as a result of changing flow regimes. All indications of location are therefore approximate.

Except for the initial 2.2 miles from Englebright Dam to the confluence with Deer Creek at Rose Bar, all reaches of the Lower Yuba River channel are strongly influenced by the lingering effects of historic hydraulic mining, which resulted in the discharge of approximately 684 million cubic yards of mining debris to the river and the surrounding floodplain. Although the river has eroded a channel through this debris over the years, debris is distributed throughout the reach downstream of the Narrows. The river downstream of the Narrows is thus constrained between (a) high steep walls of mining debris or (b) wide flat terraces of cobbles -- debris distributed by high flows. The low flow channel of the river is occasionally divided by cobble bars. For purposes of describing the river substrate, the CDFG (1991) classification of sediments, taken from Brusven (1977) is used here to categorize bed sediment descriptions by reach:

Size Class (inches)	Substrate Description
<0.25	coarse sand and fines
0.25 - 1.00	small gravel
1.00 - 2.00	medium gravel
2.00 - 3.00	large gravel
3.00 - 6.00	small cobble
6.00 - 9.00	medium cobble
9.00 - 12.00	large cobble
12.00 - 24.00	small boulder
> 24.00	medium boulder to bedrock

CDFG (1991) notes the influence of mine tailings on the availability of spawning sized sediments, concluding "Because of the tremendous volumes of gravel remaining in the river, it is unlikely that spawning gravel will be in short supply in the foreseeable future.

Armoring of the channel bed (rendering suitable spawning gravels inaccessible to spawners by development of an immobile layer of cobble over the useable gravel beneath) is possible, but has not developed to date." Such armoring now occurs in some reaches of the Lower Yuba River, particularly the upstream portion of the Parks Bar Reach (ENTRIX field observations, September 11, 2002)

2.4 RIVER CHANNEL CHARACTERISTICS: SPAWNING REDDS AND REARING CONDITIONS

2.4.1 ROSE BAR REACH

Geomorphology

In the 4-mile Rose Bar Reach below Englebright Dam, the river initially passes through a sheer rock gorge, characterized by steep rock walls and long deep pools. Deer Creek enters the river about 0.8 miles downstream of the dam. About 2.2 miles downstream from Englebright Dam, the gorge widens at Rose Bar, and there are wide flat cobble bars (flood terraces) on both sides of the channel. On the north side of the channel, there is a large crescent-shaped area of reworked mine debris, approximately 2000 feet long by up to 800 feet wide and about 10 to 20 feet in height. This portion of the river has an average gradient of about 25 feet per mile and consists of deep pools alternating with riffles and runs. The relatively high-energy of flow in this reach has scoured sediments to bedrock in a number of locations, creating several long deep pools and a relatively complex stream morphology. Releases from Englebright Dam maintain sediments free of fines and low water temperatures result in very little algal build up compared to downstream locations. There is little woody debris.

As the river winds its way around Timbuctoo Bend, the channel consists of a series of long pools linked by moderately steep riffles and short run/glide sections. The shoreline at about 900 cfs is lined with small to medium cobble and there are numerous cobble bars in mid channel as well. The reach ends at the Quarry at Parks Bar, just upstream from the Highway 20 bridge, where the river exits the confines of the foothills and enters an area of lower terraces.

Spawning Habitat

The distribution and relative abundance of spawning habitats, characterized by areas of sediments in the gravel-to-small-cobble size range, varies from reach to reach, primarily determined by localized river geomorphology. Consistent with relatively high flow velocities and a sinuous river channel, the channel substrate in the Rose Bar Reach is relatively free of fine silts and sands. In this reach, there are also numerous segments of the river where gradient changes quickly, such as at the head of riffles. These provide for an elevation drop in the vicinity of spawning gravels at the head of the riffles and along their edges. Such areas have been associated with higher dissolved oxygen concentrations in intragravel flow (Mesick 2001). Dissolved oxygen concentration is an important determinant of redd site selection and egg incubation success. Because this reach is characterized by a series of short riffle-run-riffle sequences, spawning gravel and inter-gravel conditions may be considered good.

Water temperatures in the Rose Bar Reach are almost always below 60°F, and during spawning and egg incubation periods are generally below 55°F (CDFG 1991). In this 4-mile reach, recent spawning surveys provide an indication of the available spawning habitat (Table 1). The reach also provides good rearing habitat conditions – deep cool pools with variable substrate typical of natural rearing conditions.

Table 1. Results of 2000 and 2001 Spawning Redd Surveys, Rose Bar Reach

Data Source	Year	Run	Redds	Redds per Mile
CDFG	1998	Spring	130	32.6
CDFG	2000	Spring	155	38.8
JSA	2000	Fall	305	76.4
USFWS – Unpublished data	2001	Fall	291	73
USFWS - Unpublished data	2001	Spring	151	37.8

2.4.2 PARKS BAR REACH

Geomorphology

In this reach below Highway 20, the river floodplain widens to over 1000 feet and is characterized by a less sinuous channel flowing through areas of wide, flat fluvial terraces, generally consisting of cobbles and smaller sediments. River gradient in this reach is about 10 feet per mile. There is sparse immature riparian on these terraces, suggesting relatively frequent inundation and erosion of the terraces. Cobble terraces become wider and multiple terraces become more common. September 2002 field observations under low-flow conditions (~900 cfs) found long reaches of cobble barren downstream from the Highway 20 bridge. This substrate gradually transitions to medium to large cobble, again without significant areas of finer gravel-to-small cobble substrate, as the river approaches Daguerre Point Dam. Riffles are dominated by large cobbles and small boulders. Spawning-sized gravels are sometimes found along the margin of the cobble bars and in backwater areas of side channels (See Photo 1).

In the first 1 to 2 miles of the Parks Bar Reach, the channel substrate in run-glide sections consists of large cobbles to small boulders. This “cobble barren” generally lacks spawning-sized sediments and effectively armors the channel. At Long Bar, about 2 miles downstream from Parks Bar, the river enters the Yuba Goldfields and there are extensive remnant mine tailings along both the north and south shoreline (See Photo 2).

Photo 1. Spawning gravels along the channel margin in the Rose Bar Reach (September 11, 2002)

Photo 2. Mine tailings along the shoreline of the Lower Yuba River in the Rose Bar Reach (September 11, 2002)

In some locations, the low flow channel abuts these tailings, exposing a layer of medium rock (12 to 24 inches) which extends about 2 feet above the water line at 900 cfs. For the first 2.5 to 3 miles of the Parks Bar Reach, the river channel is therefore relatively uniformly armored by large cobbles to small boulders (See Photo 3). As CDFG (1991) suggests, this probably represents a relatively stable long term condition.

Photo 3. Section of river channel with cobble/small boulder channel armoring, lower Rose Bar Reach (September 11, 2002)

The direct effects of Daguerre Point Dam and training dikes along the south shoreline on river gradient and riverbed composition begin to appear at Dry Creek, about 1 mile downstream from Long Bar, where the riverbed elevation begins to approach the dam crest elevation and the channel gradient is lower. In the reach from Dry Creek to Daguerre, the river is dominated by wide shallow runs and glides and low gradient riffles, with few pools. Flow velocity at 900 cfs is noticeably slower in this area, and the lower energy of the flows is reflected in the riverbed composition, which rapidly transitions from cobbles and rock to a gravel-cobble composition, except in the faster flowing sections of riffles, which mainly consist of medium to large cobbles, with intermittent small bounders.

Spawning Habitat

Based on year 2001 spawning redd surveys by USFWS (Table 2) and a September 2002 field survey by ENTRIX, the upstream 2 to 3 miles of the Parks Bar reach shares some characteristics with the Rose Bar Reach. Although the river gradient is somewhat less steep, riffles remain relatively steep (perhaps 50 to 75 feet per mile) and are separated by run-glide sections ranging from as little as 100 yards in length to as much as 500 yards in length. Spawning gravels are concentrated along the edge of the channel, generally upstream of riffle sections, although USFWS identifies some redds within the channel. About a mile upstream from Dry Creek, the river channel gradient becomes less steep and the ratio of run/glide habitat to riffle habitat increases (CDFG 1991). With fewer riffles per mile than in upstream areas, there are fewer opportunities for spawning habitat at the head of riffles where oxygenation is enhanced. In these slower-moving sections, the channel substrate also becomes finer, with a greater proportion of gravels and small cobbles.

Egg incubation and juvenile rearing conditions may be somewhat less desirable in this reach. Water temperatures at Daguerre Point Dam are generally low, but under low flow conditions in the summer and early fall temperatures may sometimes exceed the preferred range for salmon and steelhead (CDFG 1991).

Table 2. Results of 2000 and 2001 Spawning Redd Surveys, Parks Bar Reach

Data Source	Year	Run	Redds	Redds per Mile
CDFG (1998)	1998	Spring	76	12.0
CDFG (2000)	2000	Spring	50	7.9
JSA (2000)	2000	Fall	180	28.4
USFWS – Unpublished data	2001	Fall	360	57
USFWS – Unpublished data	2001	Spring	88	13.9

2.4.3 DAGUERRE REACH

Geomorphology

The Daguerre Reach begins at the dam itself. The dam is reinforced concrete structure with an ogee-shaped cross section of uniform crest elevation. Flow over the crest is a relatively uniform sheet flow down the ogee-shaped dam face. There is a 15-to-20-foot deep pool at the base of the dam, with virtually no sediment covering the concrete footing of the dam. Water from this pool collects behind a wide cobble bar on the south shore of the river and flows through a narrow riffle between a high bank (on the north) and this wide cobble bar on the south. There are fish ladders on both abutments of the dam.

Below the dam, the river gradient decreases to about 6.5 feet per mile (CDFG 1991) and the floodplain widens. In general, the river in this reach is characterized by short wide riffles and long, flat glides. At a flow of approximately 900 cfs, these glides are from 1-3 feet deep with some sections of shallow pools. Exceptions to these habitats occur where rock groins have been constructed and have created hydrologic complexity during higher flows. In these areas, the river channel exhibits localized scour near the groins, and there are areas of suitable spawning gravel alternating with deep pools. Except where these anomalies have altered bed-forming processes, the channel tends to have a uniform cross-section and substrate consisting of medium gravel to small cobble, with fine sediments intermixed with gravels. The cobble bars that border the river in this portion of the Daguerre Reach are wide and relatively low in elevation.

Spawning Habitat

A majority of the Daguerre Reach has a gravel/cobble size substrate that is nominally appropriate for spawning. In mid-September 2002, at about 900 cfs, there was fairly uniform shallow depth (1-3 feet) of long flat run/glide areas that fell within the depth range that CDFG (1991) specified as preferred for spawning of chinook salmon. USFWS 2001 surveys, for the spawning period in October, November, and December identified many spawning redds in midstream in this reach (Table 3). In years when periods of low flow extend into the spawning season, such as drought years, the relatively flat gradient of this reach in late summer and early fall combined with higher water temperatures may affect spawner condition and may not be conducive to optimum egg survival or incubation. Water temperatures in this reach may exceed 65°F in late summer and early fall, especially if flows are low (CDFG 1991). Based on CDFG (1991) temperature modeling, water temperatures in this reach would generally be favorable for rearing of chinook salmon, most of which would emigrate downstream prior to periods when flow/air temperature conditions would raise water temperatures in the late spring to early summer. Juvenile steelhead, which rear year-round may be adversely affected by summer temperatures in this reach.

Table 3. Results of 2000 and 2001 Chinook Salmon Spawning Redd Surveys, Daguerre Reach

Data Source	Year	Run	Redds	Redds per Mile
JSA	2000	Fall	370	54.4
USFWS – Unpublished data	2001	Fall	691	101.6
CDFG - Unpublished data	2001	Spring	Not surveyed	Not surveyed

2.5 River Channel Characteristics: Flow Regimes and Their Implications

The natural (pre-dam) flow regime in the Lower Yuba River was characterized by high peak winter and spring flow, followed by a rapid decline in flow as snowmelt decreased during the summer and early fall (CDFG 1991). Based on an analysis of flow from 1921-1983 (data from USGS gaging stations) and 1969-1988 (data from USGS gaging stations), mean monthly peak flow under natural conditions occurred in May. Mean monthly low flow occurred in September, and was only about 5 percent of peak flow. Construction of numerous upstream reservoirs has altered this hydrologic regime considerably. Mean monthly peak flow now occurs in February, with mean monthly low flow occurring in October. Mean monthly low flow is now about 25 percent of mean peak flow. The effect of storage and subsequent release of water for irrigation has therefore been to reduce month-to-month flow variation in the river. This shift in the pattern of peak and minimum flows, combined with lower peak flows and higher low flows, influences the geomorphology of the Lower Yuba River. For example, there are fewer very high flows to scour large sediments from the system.

Nonetheless, the study reach of the Yuba River sustains variation in within-year and between-year flows. Upstream of Marysville, at the USGS Smartville Gauge, maximum winter flows during the period 1972 to 1988 (covering the period for which water temperatures were modeled by CDFG in their 1991 report) exceeded 20,000 cfs in 6 of 17 years. During the same period, minimum flows were below 1,000 cfs in 14 of 17 years. The lowest flow at Smartville during this period was 140 cfs in September of 1977, and the highest maximum flow was 87,200 cfs in February of 1986. Despite the dampening effects of upstream reservoirs, intra-annual and intra-month flow variations are common. February 1986 flows varied from a low of 2,360 cfs to a high of 87,200 cfs. In dry years, such as 1976-77 and 1988, the dampening effect of reservoirs is more apparent. In 1977, for example, the range of flow over the year was 140 cfs to 711 cfs, and in 1988 it was from 522 cfs to 1,580 cfs. These low flows are probably the result of drought combined with reservoir operation. Infrequent and very large flood discharges are only somewhat dampened by the effects of dam storage. The maximum discharge at Smartville prior to the completion of New Bullards Bar Reservoir was 171,000 cfs on December 22, 1967. Post construction maximum flow was 134,000 cfs on January 2, 1997.

The reduced variation in the flow regime has probably resulted in a more stable river channel. This is evident by the presence of a large cobble to small boulder-sized armor layer along the banks of the river, at the base of training dikes and the river bed. Although the mining debris consists of materials ranging from fines to boulders, the river has access to this debris at the training dikes only at relatively high flow, and thus recruitment and distribution of smaller sediments is limited. At the same time, the de facto armoring of the riverbanks and bed by larger cobbles and small boulders limits channel migration and habitat complexity. It is therefore not surprising that under low-flow conditions, there is relatively uniform substrate and little geomorphological complexity to the channel from riffle to riffle. CDFG (1991) concluded that: "The available evidence indicates that the Lower Yuba River is probably now in equilibrium with prevailing water and sediment discharge.

The distribution and quality of riparian vegetation is affected by the bed and bank armoring and the flow regime on the Yuba River. CDFG (1991) notes that most of the river is not shaded by riparian vegetation (1986 aerial photography), and a September 11, 2002 qualitative habitat survey by ENTRIX confirms this observation. Under current conditions, most of the cobble bars in and adjacent to the channel are either sparsely vegetated or are vegetated by immature willows. Willows on the shoreline bars are often 20 to 50 feet from the edge of the low flow channel, and would probably not be affected by average flows; that is flow velocities and depths from average year high flows may not mobilize cobbles or generate forces capable of scouring the soils in the vicinity of the vegetation. Very high flows, deep enough to submerge the bars and cause cobbles to be moved, may occur every 5-10 years, resulting in scour of willows and other vegetation.

The sparseness and immaturity of riparian vegetation may also be a function of the narrow floodplain. Prior to hydraulic mining and the construction of the dam and associated training dikes, the floodplain in this reach would have been wider. Flows would have broken out of the channel and then spread out over a wide area. Damage to riparian vegetation would have been concentrated in the vicinity of the breakout point, and remaining vegetation would not have been lost. CDFG (1991) suggests that the river would thus have been bordered by riparian forest up to the 100-year flood elevation. Given that flood flows would have spread out over a wide floodplain in lower reaches of the Yuba River, it is probable that riparian vegetation would have grown to maturity and would have provided riparian shading to the river.

Flow regimes during fall-run and spring-run chinook salmon migration to spawning areas (Table 4) show the influence of irrigation diversions during both of these runs. In months when irrigation diversions are taking place, flows at the Smartville gauge just below Englebright Dam are routinely higher than those at Marysville, with the difference attributable to irrigation diversions. These periods, generally beginning in April and ending in early September, would coincide with the upstream migrations of spring-run chinook salmon (March - July) and the fall-run chinook salmon (August - November).

Table 4. Mean monthly flows for Lower Yuba River, at Smartville and Marysville, 1994 – 2001 (from USGS)

Month and Site		**Mean Monthly Flow for Year of Record**							
		1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
JAN	Smartville	1168	6254	2528	22350	3916	3449	1514	921
	Marysville	1209	7782	2955	26179	5461	4020	1651	828
FEB	Smartville	924	4542	10110	5424	7176	5600	4227	789
	Marysville	1180	5349	11060	6283	10030	7597	5819	1028

MAR	Smartville	938	13060	4438	3420	5185	5325	4846	726
	Marysville	1046	14080	5375	3522	6398	6025	5774	861
APR	Smartville	838	5611	3905	1892	4632	3337	2882	956
	Marysville	515	5910	4621	1441	5505	3659	2891	803
MAY	Smartville	1001	10350	9025	1472	5026	2576	2222	975
	Marysville	418	9721	8675	769	5348	2215	1708	302
JUN	Smartville	1054	7652	2844	1079	7360	2466	1710	966
	Marysville	280	7029	2244	367	7331	1941	959	264
JUL	Smartville	869	3564	2165	1888	2985	2342	1631	1984
	Marysville	118	2897	1292	1146	2284	1651	845	1369
AUG	Smartville	1024	2057	2400	2236	2884	2693	1639	1699
	Marysville	428	1325	1602	2051	2214	2147	1053	1270
SEP	Smartville	604	1117	1154	773	1712	1282	1082	667
	Marysville	436	862	1000	601	1453	1161	958	522
OCT	Smartville	700	1245	1504	1141	1239	1168	1079	na
	Marysville	450	964	1145	800	1032	867	782	na
NOV	Smartville	696	1191	1321	1187	1707	1042	1044	na
	Marysville	532	903	1040	961	1948	720	642	na
DEC	Smartville	803	2008	7653	1302	2681	1019	1019	na
	Marysville	920	1986	8036	1315	2732	764	696	na

2.6 RIVER CHANNEL CHARACTERISTICS: WATER TEMPERATURES

This section discusses general trends in river water temperatures, primarily based on the 1991 CDFG modeling efforts. More detailed discussion of water temperatures related to specific reaches and salmonid runs is provided in later sections of this report. CDFG (1991) modeled water temperatures using the 1972-1978 and 1987 period of record and drew the expected conclusions that:

- Dam construction has generally resulted in colder water throughout the Lower Yuba River from July to mid-December and warmer water from early March through mid-June, with little change in water temperature from mid-December through early March.

- Temperatures increase as release rates decline and as flows pass downstream, and are affected by irrigation water diversion (which reduces flow) and irrigation return flows (which increase water temperature).

- Water temperatures are a function of air temperature.

While these general conclusions are expected, CDFG (1991) notes that water temperature in the area immediately downstream of Englebright Dam are generally within the preferred range for spring-run chinook salmon migration and holding but often exceed preferred spawning and egg incubation temperatures. This is to be expected given that spring-run chinook salmon historically migrated to and spawned in higher elevation portions of the Yuba River and its tributaries, where lower air temperatures, springs, and shading would have maintained generally lower water temperatures. CDFG (1991) further notes that their model runs predict that temperatures at Marysville will frequently exceed preferred migration, spawning, and egg incubation temperatures. As CDFG (1991) notes, the condition of spawners and of their eggs, may be influenced by temperatures during migration from the ocean to spawning grounds. CDFG (1991) model predictions provide a useful basis for general analysis of temperature/flow relationships on a seasonal basis. As CDFG (1991) notes, actual field conditions may vary.

In general, however, water temperatures immediately downstream from Englebright Dam (Rose Bar Reach) seldom exceed 58°F (CDFG 1991, although model results for a warm June predict temperatures in excess of 62°F. When discharge from Englebright is greater than about 1,300 cfs and diversions for irrigation are less than 245 cfs, temperatures rise by about 6 to 8 degrees between Englebright Dam and Daguerre Point Dam (CDFG 1991, for warm June weather). Some of this effect may be a function of irrigation diversions about 1 mile upstream from the dam, but a majority of the effect is a function of ambient air temperatures. In addition, retention of spring runoff by upstream reservoirs in drought years may reduce the flows in this reach. For lower discharges, however, the CDFG (1991) model simulations predict temperatures rise rapidly in a warm June, from 58°F at Englebright Dam to up to 75°F at Daguerre Point Dam and higher temperatures downstream. These are extremes, and predicted egg incubation temperatures during October and November tend to be much lower, even for warm weather flows of about 1200 cfs:

Table 5. Simulated Lower Yuba River Average Monthly Water Temperature[1].

	Englebright Dam	Daguerre Point Dam	Marysville (Feather River)
October	52.7°F	56°F	62.6°F
November	49.0°F	51.0°F	54.5°F

1. From CDFG 1991.

By October, even in a warm year, water temperatures are suitable for spawning and egg incubation upstream of Daguerre Point Dam, but remain above preferred temperatures at the mouth of the Yuba River near Marysville; this suggests that adult fall-run chinook salmon may be exposed to high water temperatures throughout their migration, with potential adverse impacts on the condition of spawners and their eggs. In all but “cool” years, spawning and egg incubation temperatures in the reach between Daguerre Point Dam and the Feather River is simulated to be less than optimum from June through October when releases from Englebright Dam are less than about 1245 cfs and discharge at Daguerre Point Dam are less that 400 cfs.

Although there have been changes in reservoir operation since the CDFG analysis, measured temperatures at Marysville are often outside of the preferred migration and spawning range during summer and fall, with a normal maximum daily temperature range of 68°F to 70°F. It should be noted that these high temperatures would generally affect fall-run chinook salmon and not spring-run chinook salmon, which would have passed through this reach in May and June. Also, Moyle (2002) notes that spring-run salmon hold in deep pools where water temperatures seldom exceed 69.9°F to 77°F. Given that salmonids may apparently hold in pools with temperatures exceeding the preferred range noted by CDFG (1991) and taking into account the high variability of flow in Central Valley rivers and streams under natural conditions, one would expect that salmon would have some tolerance for temperature conditions well outside of the preferred range. The extent of this tolerance is not well defined in the literature.

Recognizing the potential for salmonids to tolerate temperatures somewhat higher than optimum, CDFG (1991) establishes the following temperature regime objectives:

Mid-October through March:	Daily average water temperatures should not exceed 56°F upstream of Marysville, or 57°F at the Marysville gauge.
April through May:	Daily average temperatures should not exceed 60°F at the Marysville gauge.
June:	Daily average temperatures should not exceed 65°F at the Marysville gauge.
July through August:	Daily average temperatures should not exceed 65°F at Daguerre Point Dam.
September:	Daily average temperatures should not exceed 65°F at Marysville gauge
Early October:	Daily average temperatures should not exceed 60°F at Marysville gauge.

CDFG (1991) further recommends reservoir operations to keep daily maximum water temperatures from exceeding the above daily average temperatures by more than 2°F. These temperatures are not controlled by the operation of Daguerre Dam.

2.7 HABITAT SUITABILITY AND SPAWNING USE BY REACH

While the suitability of spawning and rearing habitats in the three reaches of the Lower Yuba River may be inferred from the temperature, flow, and other physical characteristics of the river discussed above, spawning data provide an additional perspective on habitat suitability and introduces other factors into the analysis of the influence of Daguerre Point Dam on salmonids in the Lower Yuba River. It is important, first, to recognize that salmon spend only a small portion of their lives in freshwater (although steelhead may spend a significant portion of their lives in freshwater). Ocean factors such as harvest and the availability of food may affect salmon populations significantly and affect the interaction of salmonids and the available freshwater habitat. For example, if good ocean conditions result in a large adult escapement, spawning habitat may be overwhelmed, with extensive redd superimposition affecting spawning success, egg survival, and subsequent juvenile populations. In contrast, poor ocean conditions may generate low escapement, resulting in underutilization of available habitat.

It is therefore necessary to analyze habitat suitability in the context of data on spawning and rearing use of the habitat in the Lower Yuba River and data on total escapement.

2.7.1 FALL-RUN CHINOOK SALMON

JSA and USFWS conducted redd surveys in 2000 and 2001, respectively. Combined with recent carcass survey/escapement data for the Lower Yuba River, these recent surveys are perhaps the most reliable indication of the availability of suitable spawning habitat in the river. Redd selection and spawning are volitional, and the salmon's choice of spawning locations is probably a more accurate reflection of the suitability of habitat than methods based on a fixed set of physical criteria. JSA (2001) estimated total escapement for these three reaches, from 1994 to 2001, based on carcass surveys (Table 6). Redd counts and escapement for 2000 and 2001 are summarized on Table 7.

Table 6. Lower Yuba River Fall-Run Chinook Salmon Spawning Escapement Estimates, 1994-2001.

Year	Rose Bar Reach			Parks Bar Reach			Daguerre Reach			Totals		
	Adults	Grilse	Total	Adults	Grilse	Total	Adults	Grilse	Total	Adults	Grilse	Total
1994	1717	2177	3894	3800	1208	5008	1545	873	2418	7062	4258	11320
1995	2060	197	2257	6146	463	6609	5086	609	5695	13292	1269	14561
1996	8599	1614	10213	7308	1371	8679	7265	1363	8628	23172	4348	27520
1997	6194	1231	7425	6949	2577	9526	5832	2995	8827	18975	6803	25778
1998	6443	1354	7797	8854	1655	10509	10368	2128	12496	25665	5137	30802
1999	4256	675	4931	5185	2276	7461	8412	2263	10675	17853	5214	23067
2000	4135	437	4572	4970	890	5860	3816	601	4417	12921	1928	14849
2001	7863	544	8407	7721	931	8652	5265	60	5325	20849	1535	22384

Source: JSA 2001.

Table 7. Lower Yuba River Fall-Run Chinook Escapements and Redd Survey Data for 2000 and 2001.

Reach	Adult Escapement	Redds	Redds per Mile	Adults per Redd
2000				
Rose Bar	4135	305	76.4	13.5
Parks Bar	4970	180	28.4	27.6
Daguerre	3816	370	54.4	10.3
TOTAL	12921	855	49.9	15.1
2001				
Rose Bar	7833	291	73	26.9
Parks Bar	7721	360	56.8	21.4
Daguerre	5265	691	101.6	7.6
TOTAL	20849	1342	78.3	15.5

Source: JSA 2001, Unpublished data from USFWS 2002

The highly variable adult escapement from 1994 through 2001 (from 7,000 to 26,000 adults) and the high ratio of adult salmon to redds throughout the Lower Yuba River both suggest that conclusions about the availability of suitable spawning and rearing habitat must be caveated to reflect a variable population. To some extent, the data on Tables 5 and 6 may reflect errors inherent in escapement estimates and redd surveys (although confidence intervals are not provided in the cited literature).

Spawning in the Yuba River may occur over a period of several months and a bi-monthly redd survey will often undercount redds. The USFWS redd count, involving counts from boat and shoreline on the river at various times during the period from November 13 to December 7, 2001, would also undercount because spawning occurring after a given reach was surveyed would not be included in the count. The JSA redd counts, taken from aerial photographs would also probably undercount total redds. There is expected error in estimates of escapement as well. It is probable that spawner-to-redd ratios therefore overstate the density of spawning at each redd site, but there is no analysis of potential error in the data cited.

Nonetheless, these data and the consistent high percentage of total escapement in reaches upstream of Daguerre Point Dam (Table 6) suggest that either (a) fall-run chinook prefer the spawning habitat upstream at Parks Bar and Rose Bar or (b) that fall-run chinook salmon that pass the fish ladders at Daguerre Point Dam are forced to spawn upstream regardless of habitat quality because the dam forms a downstream passage barrier. That is, that adult salmon would avoid downstream passage over the face of the dam. Given that fall-run chinook salmon are emigrating to spawn in August and September, when downstream temperatures may exceed the preferred range for spawning (and egg incubation), the first conclusion is more likely to be valid. CDFG (1991) predictions of temperature near Englebright Dam would appear to be more favorable than at downstream locations. This would be particularly true for spring-run chinook salmon and steelhead whose life history would mandate seeking colder water for summer holding, spawning, and juvenile rearing. The available data are not robust enough to allow for a statistical analysis of the relative importance of temperature and/or other factors in the selection of various reaches by spring-run and fall-run chinook salmon and by steelhead. Nevertheless, as Mesick (2001) indicates, salmon generally prefer colder, well oxygenated sites for spawning and these are more abundant upstream of Daguerre Point Dam than downstream.

The "choice" of fall-run chinook salmon to spawn upstream of Daguerre Point Dam, and to spawn in the highest concentrations in the Rose Bar Reach, is consistent with CDFG (1991) conclusions that the greatest amount of weighted usable area (WUA), derived using IFIM methods, for both spawning and rearing occurs at relatively low discharges (Table 8) and in upstream reaches other than the narrows area (Table 9).

Table 8. Flow for Optimum WUA Rearing and Spawning Area for Fall-Run Chinook Salmon, Lower Yuba River.

Reach	Spawning (cfs)	Rearing (cfs)
Narrows Reach	800	300
Garcia Gravel Pit Reach	700	100-350
Daguerre Point Dam Reach	450-500	200
Simpson Lane Reach	700	100

Source: CDFG 1991.

Table 9. Calculated Maximum WUA for Spawning and Rearing for Fall-Run Chinook Salmon, Lower Yuba River.

Reach	Spawning (thousands of square feet)	Rearing (thousands of square feet)
Narrows Reach	< 100	< 100
Garcia Gravel Pit Reach	3,200	4,500
Daguerre Point Dam Reach	2,500	3,800
Simpson Lane Reach	< 200	500

Source: CDFG 1991.

Based on early September 2002 (ENTRIX, field notes September 11 2002) observations of the river channel at relatively typical flows for the post-irrigation season of September and early October of 950 to 600 cfs, (upstream to downstream) these flows (1) provide for inundation of finer gravel fractions along the channel margin in upstream reaches of the river and (2) maintain shallow depth across a majority of the flat shallow run/glide habitat in the lower reaches of the river, described under "Geomorphology," above.

CDFG (1991) concluded that spawning habitats are optimized at these relatively low flows, primarily because "run/glide" habitats accounted for 67,193 feet (52.6%) of the total of 127,700 feet of the studied river reaches. Beginning about a mile downstream from Parks Bar, these run/glide areas have well-distributed spawning-sized gravels and small cobbles. Because much of the river channel below Parks Bar is characterized by long glides or runs which are less than 4 feet deep at 900 cfs, run/glide spawning habitat is optimized at releases from Englebright of 900 to 1000 cfs, resulting in flows from 1,000 cfs (upstream) to 400 cfs (downstream at Marysville). Because salmon tend to spawn in water less than 4 feet deep (CDFG 1991), these habitats make up a vast majority of the habitat identified as suitable in the CDFG (1991) analysis. Higher flows would raise water levels, inundate adjacent cobble and small boulder bars along the river channel, and increase the depth over these areas and in the main channel. However, the

CDFG (1991) analysis of weighted usable area useable area did not take into account temperature or potential for well-oxygenated gravels.

The CDFG (1991) analysis conflicts with the 2000 and 2001 redd counts. The redd count results found a majority of redds along the channel margin. In contrast, the CDFG IFIM analysis predicted greater spawning in main-channel river habitats. Main channel redds appear to increase in proportion to total redds in lower river locations, where channel configuration is more uniform. But the 2000 and 2001 distribution and density of spawning redds suggests that spawning and rearing habitat is in fact more suitable in upstream locations and at perhaps somewhat higher flows than predicted by CDFG in 1991. This conclusion is based on:

- USFWS 2001 redd surveys. Maps prepared from USFWS GPS coordinates, suggest a preference for channel margin and side channel locations over in-channel spawning (See USFWS GPS redd survey coordinates, Attachment 1 and Entrix maps prepared from these coordinates, Attachment 2);

- The 2000-2001 redd surveys. These show 73 to 76 redds/mile in the Rose Bar reach, which CDFG 1991 identifies as having very little "preferred" run/glide habitat, while there were only 29 to 57 redds/mile in the Parks Bar Reach, which has about 15 times as much run/glide habitat;

- CDFG temperature modeling, which shows that temperatures during warm weather and low discharges exceed the preferred spawning and egg incubation temperatures for chinook salmon and steelhead in the downstream locations where run/glide habitat is most common.

Unfortunately, 2000 and 2001 are the only years for which fall-run chinook salmon redd counts and escapement estimates are both available in the literature. But the escapement estimates shown on Table 6 indicate that fall-run chinook salmon spawning above Daguerre Point Dam is routinely higher than it is below the dam, and this may readily be explained by the higher water temperatures in the reach below the dam, and perhaps by the lower velocity flows. Mesick (2001) notes that in the Stanislaus River, spawning redds were concentrated in areas where the local streambed gradient was increasing (at the head of riffles, for example). Selection of such sites for spawning would provide for good intra-gravel flow. Such areas are less common in the Daguerre Reach than in the upstream reaches. In short, spawning habitat appears to be of better quality in upstream reaches and is utilized accordingly.

2.7.1 Spring-run Chinook Salmon

There are few data on spawning of spring-run chinook salmon. CDFG (1999) identified 206 total spring-run redds above Daguerre Point Dam in 1998, 130 of them in the Rose Bar Reach and 76 in the downstream Parks Bar Reach. In 2000, CDFG (2002a) identified 205 spring-run spawning redds, but only 50 of them in the Parks Bar Reach. USFWS (2001) redd surveys identified 151 redds in the Rose Bar Reach and 88 redds in the Parks Bar Reach. Because initial surveys for 2000 and 2001 found no evidence of spring-run chinook salmon spawning in the Daguerre Reach below the dam, no systematic surveys of this reach have been conducted. These redd counts are consistent with spring-run chinook life history data, and the redds upstream of Daguerre Point Dam suggest that the dam is not an absolute barrier to spring-run chinook salmon migration upstream given appropriate flow and ladder conditions at Daguerre Point Dam.

The 1998, 2000, and 2001 redd surveys provide a preliminary basis for a gross estimation of the escapement of spring-run chinook salmon on the Lower Yuba River. Given the multiple redd construction noted in these redd counts, and thus a ratio of 1.5 fish per redd, 2001 escapement for spring-run chinook salmon in the Lower Yuba River would be 433 fish. At a spawner-to-redd ratio of 2.5 to 1, the escapement would be 723 fish. These very rough escapement estimates exceed those of CDFG (2002b), which were based on spring-run chinook salmon "trapped in the fish ladders at Daguerre from 1 March to 31 March 2001." However, in 2002, CDFG (2002c) notes that "the first major push of chinook salmon for the year has been observed in the Lower Yuba River, June 4, 2002. Low population estimates for spring-run chinook salmon, based on early season migration data when high flows may affect passage at Daguerre Point Dam, may somewhat understate actual populations.

The 1998, 2000, and 2001 redd surveys also suggest that spring-run chinook salmon utilize the upper portions of the Parks Bar Reach as well as the Rose Bar Reach. This is consistent with recent field observations (ENTRIX, September 11, 2002) that the upper portions of this reach share many characteristics of the Rose Bar Reach -- numerous deep pools, relatively frequent and deep riffles, and numerous areas of spawning sized gravels along the channel margin and in areas at the head of riffles.

Finally, the 1998, 2000, and 2001 redd counts suggest that temperature regimes in the upper portions of the Parks Bar Reach and of the Rose Bar Reach are at lease minimally adequate for spring-run chinook spawning, even at the relatively low flows of August and September.

2.7.2 STEELHEAD

Because steelhead spawn in the winter and early spring when flows are generally high and water clarity may be impaired, steelhead are more difficult to survey for than chinook salmon. USFWS field notes for their 2002 survey of steelhead redds note high turbidity and very low water clarity (secchi disk readings of 6 inches) during January and February. Water clarity improved markedly in early April, and USFWS was able to identify steelhead redds during surveys on April 5 and April 23, 2002 (Table 10). The results of the USFWS 2002 survey are consistent with expectations.

Table 10. Steelhead Spawning Redds, Lower Yuba River, 2002

	Rose Bar	Parks Bar	Daguerre	All River
Reach length (miles)	3.99	6.34	6.8	17.13
Number of Redds	44	3	0	47
Redds/Mile	11	0.5	0.0	2.7

Source. Unpublished data from USFWS (2002) and CDFG (2002). The Daguerre Reach was not systematically surveyed.

2.8 HABITAT USE AND POTENTIAL FOR INCREASED HABITAT USE

The habitat upstream from Daguerre Point Dam is accessed and used by all three indigenous salmonids in the Lower Yuba River depending on flow conditions, even though passage at Daguerre Point Dam is less than optimal. Habitat conditions in the Lower Yuba River maybe less than optimal for salmonids in a number of ways:

- Areas of cobble barrens in some portions of the Parks Bar reach, where the riverbed is effectively armored by large cobbles to medium boulders. In these reaches, redd construction is difficult and therefore fall-run and spring-run chinook spawning is documented to occur only along channel margins and backwater or side channel areas with less armoring (Attachment 2).

- Lack of channel complexity. From upstream to downstream, there is a general trend away from a sinuous channel with a varying cross-section, and a mix of riffles, glides, and pools to a channel characterized by short riffles leading to long, straight, wide, shallow runs with relative uniform channel cross-section. Such complexity provides a greater potential for well oxygenated spawning redds. This lack of complexity is especially evident in the 3 miles above Daguerre Point Dam and in reaches below Daguerre Point Dam. In the Parks Bar Reach, this lack of channel complexity may be a function of the constraints on channel migration caused by training dikes (on the south boundary of the floodplain) and remnant areas of reworked mined debris.

- The general lack of spawning-sized gravels and small cobbles in the river banks along the low-flow channel, resulting in low recruitment of spawning-sized gravels in reaches such as the Parks Bar Reach. As a result, recruitment of these gravels may be limited, except when flows are high enough for the river to come in contact with the mined debris piled along its edge.

CDFG (1991) notes that the Lower Yuba River seems to have reached a dynamic equilibrium, and their characterization of the river in terms of the above characteristics is consistent with the observations of Entrix September 11, 2002 field observations.

While these habitat conditions indirectly suggest that the Lower Yuba River may have limited spawning habitat, such a conclusion cannot be supported with direct evidence. There are no long-term trend data on redd superimposition, on salmon and steelhead behavior, on the viability of eggs in areas with potentially sub-optimal intragravel flow and oxygen conditions, or on other clear indicators of a habitat limited system. Conclusions regarding the potential capacity of the habitat in various Lower Yuba River reaches to support spawning and rearing of salmonids must therefore be based on analysis of indirect indicators of the relationship between habitat and salmonid use of that habitat.

2.8.1 FALL-RUN CHINOOK SALMON

For fall-run chinook salmon, there are reasonably reliable data on annual escapement, supplemented by recent data on the number and location of spawning redds in the Lower Yuba River. These data may be compared to data from other studies to provide some insight into the potential for the Lower Yuba River to support spawning and rearing at current or expanded levels.

There have been a number of recent attempts to relate the availability of spawning habitat to escapement. For example, on the Lower Mokelumne River, Miyamoto and Hartwell (2001) found strong positive correlations between the number of spawning redds and total escapement. In their study, the ratio of total adult spawners to redds varied within a relatively small range (Table 11). Similar results were found in 1994 -1996 studies of spawning habitat suitability on a 12-mile reach of the Stanislaus River from Goodwin Dam to Orange Blossom Bridge (Mesick 2001) (Table 11).

Mesick notes that these data suggest an underutilization of habitat and multiple redd construction by females. In addition, Mesick (2001) found that most spawning (73%) occurred upstream of riffle crest areas, where gravity would enhance the flow of water and oxygen through the gravels , and that predicted egg survival was higher in these locations than in downstream of riffle crests. Mesick notes (a) that escapement in these years was much lower than the 4,800-fish mean escapement for the years 1967 through 1991 and (b) that based on stock recruitment relationships, escapement of greater than about 2,500 fish exceeds the carrying capacity of this 12-mile reach of the river.

Table 11 Ratio of Redds to Natural Spawners, Mokelumne River below Comanche Reservoir and Stanislaus River from Goodwin Dam to Orange Blosson Bridge

	Mokelumne River (Miyamoto and Hartwell 2001)			Stanislaus River (Mesick 2001)		
Year	**Redds**	**Spawners**	**Redd:Spawners**	**Redds**	**Escapement**	**Redd:Spawners**
1990-91	71	429	6:1			
1991-92	127	369	2.9:1			
1992-93	343	934	2.7:1			
1993-94	530	993	1.9:1			
1994-95	774	1503	1.9:1	714	1079	1.5:1
1995-96	888	2094	2.3:1	415	611	1.47:1
1996-97	1284	3892	3.0:1	113	168	1.48:1
1997-98	1316	3624	2.7:1			

Source: Miyamoto and Hartwell (2001) and Mesick (2001).

Although these recent analyses are not directly applicable to the Lower Yuba River, they are interesting because the spawner-to-redd ratios are almost an order of magnitude lower than those for areas upstream from Daguerre Point Dam in 2000 and 2001 (Table 5). Even assuming undercounting of Lower Yuba River redds by a factor of 3 or 4, the spawner-to-redd ratio is high. Even spawner-to-redd ratios of 4:1 or 6:1 would suggests that spawning habitat above Daguerre Point Dam is probably saturated (or else redd counts and/or escapement numbers are grossly inaccurate). The escapement data for 1994 through 2001 offer some support for a conclusion that these reaches could be spawning habitat limited in some years, where escapement numbers rise in 1994, 1995, and 1996, peak in 1998 and then decline somewhat in 1999 through 2001. At the same time, favorable ocean conditions have resulted in escapements of naturally spawned fall-run chinook salmon that have exceeded escapement targets in every year since 1995 (PFMC 2003). Under these good ocean conditions, a steady increase in escapement could be anticipated, unless spawning habitat conditions were limiting recruitment. Another indication of spawning habitat limitation is the USFWS (2001) field notes that redd superimposition rates were up to 50 percent in some locations within the Parks Bar Reach.

There maybe limitations on available good-quality spawning habitat in the area upstream and downstream of Daguerre Point Dam, especially where the influence of the dam creates long run-glide areas when compared to Mesick's (2001) data on spawner preference for redd sites above riffles, and the better egg incubation conditions at above-riffle sites. These areas may have suitable gravel composition (especially from Long Bar downstream), but few of them would appear to provide the conditions for significant intragravel flow and associated good intragravel oxygen conditions.

High spawner-to-redd ratios and evidence (field observations) of sub-optimal spawning habitat in the cobble barrens and the long glide-run segments of river in the Parks Bar Reach would suggest that, at least when escapement is high, the Lower Yuba River may be spawning habitat limited, particularly upstream of Daguerre Point Dam, which is utilized by a substantial majority of fall-run chinook spawners in most years.

2.8.2 Spring-Run Chinook Salmon

Spring-run chinook salmon generally begin to spawn about a month before fall-run chinook salmon. Virtually all spawning habitat upstream of the dam would therefore be available to them without significant competition from fall-run chinook salmon, at least in September and early October. If spring-run chinook salmon escapement was large, the number of redds per mile would be high. Instead, it is lower than that for fall-run chinook salmon (Table 12), suggesting lower escapement of spring-run chinook salmon than fall-run chinook salmon.

Table 12. Density of Spring-run Chinook Salmon Reds and Fall-run Chinook Salmon Redds in the Lower Yuba River, by reach

	Spring-run		Fall-run	
	Redds	**Redds/Mile**	**Redds**	**Redds/Mile**
		2000[1]		
Rose Bar	155	38.7	305	76.4
Parks Bar	50	12.5	180	28.4
Daguerre	NA	NA	370	54.4
		2001[2]		
Rose Bar	151	37.7	291	73
Parks Bar	88	22.0	360	56.8
Daguerre	NA	NA	691	101.6

1. From CDFG 2002a; 2. From USFWS 2001

Without accurate escapement estimates for spring-run chinook salmon, it is not appropriate to speculate on whether spawning habitat is over or under utilized by spring-run chinook salmon in the Parks Bar and Rose Bar reaches. But the lower density of spawning redds suggests that there is some potential for enhanced use of spawning habitats in these reaches. The fact that there is no spring-run chinook spawning in the reach below Daguerre Point Dam is also an indication that spring-run chinook salmon are able to utilize the existing fish ladders at the dam, after some delay in early spring, when flows drop below 2,000 to 2,500 cfs. CDFG (1991) and USFWS (Biological Opinion, 2000) hypothesize that migration delays at the dam may also have sublethal effects on spawning condition and thus spawning success of fish that do pass upstream and may also cause some fish to return to the Feather River and stray to other watersheds in search of suitable spawning habitats. These hypotheses have not been confirmed, and tracking of spring-run chinook salmon in the Lower Yuba River would be necessary to determine actual passage rates and the effects of delayed migration on spawning condition.

2.8.3 STEELHEAD

The steelhead redd surveys for 2002 suggest that, as would be expected, steelhead spawning is concentrated in upstream reaches. Steelhead generally choose finer gravel/cobble substrate for redd construction than chinook salmon. The preponderance of larger cobble and small bounders in the upstream portions of the Parks Bar and Rose Bar reaches, particularly in areas of "cobble barrens," would suggest that habitat availability and quality may be a limiting factor for steelhead in these reaches.

3 3.0 IMPROVED PASSAGE AND SPAWNING AND REARING HABITAT

Although it is not possible to draw any firm conclusions from 1 to 2 years of data, the high fall-run chinook salmon spawner-to-redd ratios for 2000 and 2001 indicate that the Lower Yuba River is currently spawning habitat limited for fall-run chinook salmon. It is, however, not clear that the Lower Yuba River is spawning habitat limited in low escapement years when ocean conditions are poor and ocean survival is low. Since 1971, escapement estimates for fall-run chinook salmon have been less than 6,000 in 4 years and under 10,000 fish in 11 years. Although there may be insufficient habitat to support maximum escapements in years with good ocean conditions, there is no evidence that the system is habitat limited when escapements are much lower. When ocean conditions are poor and escapements are low, migration to lower temperature spawning habitat upstream of Daguerre Point Dam may be important for maintaining populations of all three salmonids of interest.

Assuming that it is beneficial for all three salmonids of interest in the Lower Yuba River to reach and utilize the habitats upstream from Daguerre Point Dam, the extent to which improved passage provides such benefits depends on the answer to several questions:

- To what extent does the dam prevent passage?
- To what extent does the passage delay adversely impact salmonids?
- To what extent does the dam/ladder affect juvenile salmonid emigration and survival?

3.1 THE NEED FOR IMPROVED PASSAGE

There are no experimental data available to answer this question definitively; that is, there are no data on the percentage of migrating salmon or steelhead that reach Daguerre Point Dam, fail to pass the dam, and either return to a downstream location to spawn or fail to spawn as a result of delay or injury at the dam. However, the probable effects of Daguerre Point Dam on passage success may be inferred from:

- Data on spawning in various reaches of the Lower Yuba River
- Data on the function of the ladder at various flows

3.1.1 SPAWNING IN VARIOUS REACHES OF THE LOWER YUBA RIVER

Fall-run chinook salmon spawning data for the various reaches of the Lower Yuba River are available for the period 1971-1989 (Mills and Fisher 1994) and 1991 - 2001 (JSA, 1992, 1995, 1996, 1997, 1998, 1999, 2000, 2001). A majority of these data are from carcass surveys, although in 1976 and 1977, data were also collected by weir/traps (1976) and fish counter (1977) methods. These reported data for the three reaches have been used as the basis for this study. The usefulness of these data for comparative analysis is limited because prior to 1994, CDFG and JSA used an assumed value for spawning in the Rose Bar Reach (15.5 percent), and report actual carcass counts for only 5 of the 23 years from 1971 through 1993. Statistical analysis of these data sets is therefore not feasible.

For the 8-year period from 1994 through 2001, however, JSA reports data from carcass counts for the Rose Bar, Parks Bar, and Daguerre reaches (Table 6); calculated fish spawned/mile are shown on Table 13. Note on Table 13 that the value for percent of total spawning estimate for the Rose Bar Reach in 1995 is an assumed 15.5 percent, a factor CDFG (1991) based on early (1970's) estimates of actual escapement to Rose Bar. This factor is applied to data sets when the Rose Bar data are not available. However, this factor is significantly below the mean for the 7-year period of almost 31 percent (30.77 percent) and is 6 percent below the lowest percentage based on actual carcass counts. Given the relatively high percentage of the total escapement that spawned in the Parks Bar Reach in 1995, it seems probable that this assumption that only 15.5 percent of total escapement spawned in the Rose Bar Reach is faulty, and that the percentage should be adjusted upward. If it were adjusted to 21.4 percent, equivalent to the lowest percentage based on actual carcass counts, the percentage of fish spawning upstream from Daguerre Point Dam in 1995 would approach 66 percent.

Table 13. Calculated Fish Spawned per Mile and Percent of Total Spawning Estimate, Lower Yuba River, 1994-2001

	Fish spawned per mile by reach			Percent of total spawning estimate by reach		
Year	**Rose Bar**	**Parks Bar**	**Daguerre**	**Rose Bar**	**Parks Bar**	**Daguerre**
1994	976	790	403	34.4	44.2	21.4
1995	566	1042	949	15.5	45.4	39.1
1996	2560	1369	1438	37.1	31.5	31.4
1997	1861	1503	1471	28.8	37.0	34.2
1998	1954	1658	2083	25.3	34.1	40.6
1999	1236	1177	1779	21.4	32.3	46.3
2000	1146	924	736	30.8	39.5	29.7
2001	2107	1365	888	37.6	38.7	23.8
Range	566 - 2560	790 - 1658	403 - 2083	15.5 – 37.6	31.5 - 45.4	21.4 - 46.3

Source: JSA 2002.

These data, indicate that fall-run chinook salmon pass the fish ladders at Daguerre Point Dam with regularity. In 1994, 1995 (adjusted), 1996, 1997, 2000, and 2001, the total escapement to the two reaches upstream from Daguerre Point Dam was greater than 65 percent of total estimated escapement, and fish spawned per mile was also greater for the two upstream reaches. In the remaining 2 years (1998 and 1999), from 40.6 percent to 46 percent of fall-run chinook salmon spawning occurred below Daguerre Point Dam, and fish spawning per mile was also relatively high (2083 and 1799, respectively) in the Daguerre Reach. This indicates that the dam is passable to some degree in all years for fall-run chinook salmon.

Although fall-run salmon manage to pass the dam in all years, there is high variability in the percentage of spawning above and below Daguerre Point Dam. This variability could be related to flow, run timing, and ladder function. USGS discharge data at the Marysville Gauge downstream from Daguerre Point Dam and the Smartville Gauge upstream from Daguerre Point Dam were therefore examined for the fall-run migration. Mean monthly discharges at the USGS gauges for August and September 1994 through 2001 are shown on Table 14, and compared to percent spawning above Daguerre Point Dam. To determine whether flow might be affecting the percentage of fall-run chinook salmon spawning upstream and downstream of Daguerre Point Dam, mean monthly flows for the period July to December, 1994 through 2001, were compared to the percent distribution of spawning above Daguerre Point Dam, using a simple linear regression. In this analysis, August and September flows were found to be negatively related to the percent of escapement spawning upstream of Daguerre (August r = -0.86 for Smartville and -0.89 for Marysville; September r = -0.79 for Smartville and -0.77 for Marysville). The r values for all other months were below -0.6. This analysis indicates that flows within the control of Englebright Dam may affect the relative use of upstream and downstream spawning habitat. The data on Table 14 suggest that relatively low flows during August and September allow a substantial portion of the fall-run chinook salmon migrating in the Lower Yuba River to reach habitat upstream of Daguerre Point Dam. When flows at Smartville and Marysville less than about 2000 cfs, escapement upstream of Daguerre Point Dam exceeds 70% of total escapement. Lower upstream escapement is associated with flows of greater than 2000 cfs.

Table 14. Mean Daily August and September Discharge for the Lower Yuba River at Smartville and Marysville, 1994 - 2001.

	Mean August Flow (cfs)		Mean September Flow (cfs)		Percent Spawning
Year	Smartville	Marysville	Smartville	Marysville	Above DPD
1994	1024	428	604	436	78.6
1995	2057	1325	1117	862	66.8
1996	2400	1602	1154	1000	68.6
1997	2236	2051	773	601	65.8
1998	2884	2214	1712	1453	59.4
1999	2693	2147	1282	1161	53.7
2000	1639	1053	1081	958	70.3
2001	1699	1270	677	522	76.3

It should also be noted that mean monthly flow values do not reflect the high daily variability often seen in flows in the Lower Yuba River, and that these correlations should not be viewed as definitive evidence of a flow-passage-spawning effect. However, these flow-spawning correlations are preliminary indications that there is some potential effect of flow on passage and spawning. Potential mechanisms for the possible effect include:

- Higher flows (passing over the crest of the dam) may be overwhelming the flow cue from fish ladders, resulting in longer delay periods for migrating fall-run chinook salmon;

- Higher flows may be adversely affecting ladder performance, perhaps due to turbulence in the ladder or due to a higher attraction flow over the dam face relative to that coming from the ladder entrance;

- Higher flows may be enhancing downstream spawning conditions by (a) lowering water temperatures, and/or (b) scouring fines from downstream spawning areas, and/or (c) flooding more downstream spawning gravels and thus increasing the availability of spawning habitat and armored bed prevents scouring of fines; and,

- Delay caused by higher flows could increase the number of attempts to pass the dam and the injury rate to fish repeatedly making such attempts. This could decrease fitness and reduce the ability of fish to pass the ladders, resulting in more fish spawning downstream from the dam.

Whatever the mechanism, it does appear that high August and September flows may actually block passage for a proportion of the fish which might otherwise move upstream to spawn. Ladder function appears to be impaired when flows are in the 2000 to 2500 cfs range. This apparent threshold of ladder function was used as a basis for estimating the potential for higher flows to result in delayed migration of spring-run chinook salmon and steelhead.

3.1.2 PASSAGE AND LADDER FUNCTION AT VARIOUS FLOWS.

Although it is clear that flows decline in early September and the fish ladders become more passable for fall-run chinook salmon in all years, the effects of the ladders on spring-run chinook salmon are not as clear. A 2000 Corps of Engineers Waterways Experiment Station report determined that spring-run salmon and steelhead are not able to ascend the ladders at Daguerre Point Dam during “moderate to high flows” (ACOE 2000). The Corps’ report notes that the entrances to the ladders are closed when water elevation reaches 130 feet (m.s.l.) and that ther remain closed until water surface elevation reaches 127 feet (m.s.l.). The Corps’ report does not define flow at these elevations. The June 2000 USFWS "Biological Assessment of the Effects of Operations of Englebright Dam/Englebright Lake and Daguerre Point Dam on Central Valley ESU Spring-Run Chinook Salmon and Steelhead Trout" also notes the functional deficiencies that cause their failure:

- The control gate, acting as a submerged orifice, is only passable at low (undefined) flows during summer and fall;
- The ladders become clogged with debris;
- The entrances are located where the spillway overflow makes the attraction flow ineffective; and

Based on the analysis of passage versus flow shown on Table 14, it is possible to develop reasonable hypotheses about the potential for flows to delay passage for spring-run chinook salmon. While flows in excess of 2,000 cfs do not occur frequently during the fall-run chinook salmon spawning migration, they are more common during the spring-run and portions of the steelhead spawning migrations. If flows greater than 2,000 cfs, make the existing fish ladders more difficult to pass (as may be the case for fall-run chinook salmon), Daguerre Point Dam could delay upstream migration of spring-run chinook salmon and steelhead, which only spawn in the two upstream reaches. Such conditions occur relatively frequently from January through June (Table 4). In the eight year period of record shown on Table 4, mean monthly flows in excess of 2,000 cfs were recorded at Smartville in 31 out of 48 months (64 percent). Flows in excess of 5,000 cfs were recorded at Smartville in 15 of 48 months. In the 8-year period of record shown on Table 4, flows exceeded 5,000 cfs in all 6 months of the January through June period in 1995, and for at least three months of the winter-spring period in 1998. Under such high-flow conditions, passage for spring-run chinook salmon and steelhead could be delayed for an extended period.

During an extended delay, it is likely that spring-run chinook salmon would make repeated attempts to pass the dam. This could adversely affect their general condition and could result in significant injury and subsequent disease. Extended passage delay may therefore reduce the number of spring-run chinook salmon reaching spawning areas, and reduce the condition of those salmon which do reach spawning areas.

Fish ladders would also functional improperly during a majority of the steelhead spawning migration period, but steelhead may be able to pass over the face of the dam, due to their superior swimming speed and ability to jump barriers. There is thus no way to evaluate the blockage effects of the dam on steelhead.

3.2 TO WHAT EXTENT DOES THE PASSAGE DELAY ITSELF ADVERSELY IMPACT SALMONIDS?

For fall-run chinook salmon, the primary effect of passage delay would appear to be to redirect delayed fish to spawning areas downstream from the dam. Spring-run chinook salmon and steelhead are less likely to be diverted because they are not well-adapted to spawning in mainstem river systems. In addition, their life history includes routine holding in deep pools below barriers; the plunge pool at Daguerre Point Dam would somewhat mimic such natural conditions. This would mean that spring-run chinook salmon and steelhead would hold below the dam for extended periods of time and have a higher probability of eventually locating the ladder openings and passing over the dam.

For fall-run chinook salmon, the downstream spawning conditions would be characterized by shallow riffles between long shallow glide-runs. The riverbed in these areas often consists of spawning-sized gravels and cobbles, but low river gradient and associated lack of pool-riffle complexes may affect the quality of spawning redds and their suitability for successful egg incubation. In years of low escapement, forced spawning in these areas due to blocked ladders, rather than in the probably more suitable reaches above Daguerre Point Dam, could have adverse impacts for fall-run chinook salmon. Impacts to spring-run chinook salmon and steelhead are less likely, as they would have completed their passage in the spring, when water temperatures in all reaches are more favorable.

Passage delay itself would probably not induce spring-run chinook salmon or steelhead to spawn in the Daguerre Reach. Both are genetically programmed to seek spawning habitat in cooler upstream waters. But delay could have some adverse impacts on spring-run chinook salmon. As noted above, delay would likely result in repeated attempts to pass the ladders or the dam itself, possibly resulting in a higher than normal injury rate. Delay would then reduce the condition of fish reaching the spawning areas upstream from the dam. In two field trips to the dam (September 2001 and September 2002), ENTRIX biologists observed chinook salmon attempting passage over the dam face at flows of less than 1000 cfs. In these efforts, fish would leap out of the water and contact the rough concrete of the dam face at about 8 to 12 feet below dam crest, and would then fall back into the pool. It is likely that individual fish are injured by this behavior, and a brief snorkeling survey on September 11, 2002 identified fish with abrasion injuries likely to have been caused by leaping at the dam.

While there is no conclusive evidence that salmon are experiencing significant rates of injury in attempting to pass the dam, there are other reports of adult salmon sustaining significant injury when unable to pass low dams or blocked fish ladders (for example, Knapp 1992). The mechanism for such injury is also relatively obvious from observation of fish behavior at low flows. Sheet flow over Daguerre Point Dam at less than 1000 cfs may be only 3 to 6 inches deep. A salmon leaping 8 to 10 feet from the pool at the base of the dam would pass through this sheet flow and contact the rough face of the dam with some force.

Delay also impacts energy reserves of pre-spawned adults. As the June 2000 USFWS Biological Assessment suggests, delayed passage could affect energy reserves of fall-run and spring-run salmon, indirectly affecting spawning success. However, since spring-run chinook salmon life history involves a significant period of summer/fall residence in cool water habitat prior to spawning, effects on energy reserves associated with holding below Daguerre Point Dam may be no greater than those associated with normal behavior. Nevertheless, prolonged delay, with repeated efforts to pass over the face of the dam, could have such adverse effects. No data are available to quantify the potential for these effects and they remain hypothetical and in need of focused study.

Migration delay may be a function of high flows, but may also occur as a result of low flows. At a flow of about 400 to 500 cfs (September 11, 2002), Entrix biologists were unable to detect flow out of the ladders and a majority of the salmon observed in the pool below Daguerre Point Dam were concentrated in front of the dam, where the highest percentage of flow was passing over the dam face. However, an hypothesis that there are significant delay effects due to inability to locate ladders would not be supported by the negative correlations between flow and upstream spawning.

Spawning migration delays as a result of dysfunctional ladders would likely affect spring-run chinook salmon more than other salmonids because flows in excess of 2,000 cfs occur frequently during the March through July period of their spawning migration. Spring-run chinook salmon are also generally smaller and thinner than fall-run chinook salmon, and may therefore be more susceptible to injury from contact with the dam during efforts to pass the dam when ladders are not operational. Similar delays in spawning migration would also adversely affect steelhead, although some steelhead may be able to pass over the face of the dam when there are high flows.

3.3 TO WHAT EXTENT DOES THE DAM/LADDER AFFECT JUVENILE SALMONID EMIGRATION AND SURVIVAL?

3.3.1 EGG INCUBATION AND JUVENILE REARING CONDITIONS

Factors that may affect egg survival and juvenile rearing in the Lower Yuba River vary by reach (Table 15).

Table 15. Factors which may affect egg survival and juvenile rearing in the lower Yuba River, by reach.

Factor	Reach		
	Rose Bar	**Parks Bar**	**Daguerre**
Riffle-to-run ratio (length) (From CDFG 1991)	0.55:1		0.36:1
Pool-to-total habitat ratio (From CDFG 1991)	0.25:1		0.44:1
Deep pool-to-shallow-pool ratio (From CDFG 1991)	2.3:1		0.94:1
Warm April water temperature at 245 cfs (From CDFG 1991)	49° F	51° F	58° F
Warm May water temperature 245 cfs (from CDFG 1991)	54° F	56° F	65° F
Warm June water temperature 245 cfs (from CDFG 1991)	58° F	61° F	72° F
Presence of predators in March-June: smallmouth or largemouth bass (Moyle 2001)	No	No	Yes
Presence of predators in March-June: Striped bass (Moyle 2001)	No	No	Yes

Given the summary data on Table 15, egg survival through the incubation period would probably be greater in the Rose Bar and Parks Bar reaches, with their lower water temperatures and a higher percentage of riffle habitat than for the reach downstream from Daguerre Point Dam. Following incubation, rearing juveniles in the upstream reaches would have more favorable deep pool habitat (to minimize predation by avian predators), no predation pressure from warm-water piscivores, and generally lower water temperatures.

There is some indirect evidence that incubation and/or rearing conditions are, in fact, better upstream from the dam. CDFG (1991) describes the distribution and relative abundance of juvenile salmonids, based on electrofishing (February and May 1987) and snorkeling surveys (May 1988). These surveys were conducted during dry years when mean monthly discharges at Smartville were 933 cfs and 717 cfs, respectively, and mean monthly discharge at Marysville was 367 cfs and 308 cfs. CDFG found juvenile chinook salmon composed about 50 percent of all species collected. As would be expected in a system with little riparian vegetation and little woody debris, juvenile chinook preferentially used higher velocity portions of deep pools, riffles, and glides, which provide some cover from predators. There is proportionally more of this type of rearing habitat upstream than downstream from Daguerre Point Dam, suggesting potentially better rearing conditions in upstream reaches.

CDFG (1991) also reported growth from February to May for fish in all reaches, but noted that juvenile chinook salmon in the reach below Daguerre Point Dam had lower average condition factors (K) than fish from upstream reaches (combined February and May condition factors):

Narrows Reach:	1.14
Garcia Pit Reach:	1.14
Daguerre Reach:	0.90

The origin of the juvenile fish sampled in the February and May 1987 electrofishing surveys may account for the differences in condition. Because Daguerre Point Dam effectively blocks upstream passage of juvenile salmonids (juveniles are not know to use fish ladders), the juveniles sampled upstream from the dam would be progeny of upstream spawning. Fish sampled downstream from the dam would represent a mix of progeny from upstream spawning and spawning in the downstream reach itself. The lower condition factor for downstream fish reported by CDFG is consistent with a hypothesis of (a) less favorable spawning and egg incubation conditions and/or (b) less favorable rearing conditions. Predation pressure could also affect condition factor by forcing juveniles to seek less favorable habitats to avoid predators.

3.3.2 EMIGRATION

CDFG (1991) provides the only quantitative data related to the abundance and distribution of juvenile salmonids in the Lower Yuba River; data based on spring electrofishing and snorkel surveys conducted during two years of the 1987 to 1993 drought. Such data are unlikely to be representative of abundance and distribution during other years. The generally hypothesized effects on emigrating juvenile salmon include:

- Increased susceptibility and exposure to predation downstream of the dam.

CDFG surveys in 1987 and 1988, dry, low-flow years when water temperatures in May would be relatively high (above 65°F), document the presence of Sacramento pikeminnow both above and below Daguerre Point Dam. This has been verified by observation during other surveys of the spillwater pool during the ENTRIX 2002 field visit. Juveniles passing over the dam or down the fish ladders would be subject to predation in the clear, deep pool, which has little cover. It is likely that juveniles would be disoriented after passing over the dam and would be easily captured by pikeminnow. Such a conclusion would be consistent with experimental data from the Columbia River, which indicate both that juveniles are disoriented following passage over dams and that predation by pikeminnow is higher for such disoriented fish (Mesa 1994, Muir et al, 2001).

The dam does not, however, block movement of pikeminnow to upstream areas. Although, CDFG (1991) found no pikeminnow in the Rose Bar Reach, 1987 and 1988 surveys identified 114 adult pikeminnow in the Parks Bar Reach above Daguerre Point Dam, and 61 adult pikeminnow in the Daguerre Reach below the dam. Other potential predators on chinook salmon juveniles were not found or were found in low numbers during the May 1987 and 1988 CDFG surveys. Out of 8,815 fish observed during snorkeling and 1,707 fish collected by electrofishing, no striped bass were found and only 7 smallmouth bass were captured, all but one below Daguerre Point Dam.

Even in a warm year, CDFG's 1987 and 1988 observations make sense. The Lower Yuba River has little riparian, submerged macrophytic, or emergent plant habitat, or rocky channel margins suitable for an ambush predator such as smallmouth bass. In addition temperatures are generally lower in most reaches than those preferred by smallmouth bass in most months of the year (Moyle 2002). A resident population of this warm-water predator is therefore unlikely, particularly above Daguerre Point Dam with its lower temperature regimes. Adult striped bass are also unlikely to spend much of their lives in this area, and are likely to be concentrated below the long series of riffles leading from Marysville to Daguerre Point Dam.

Based on these limited data collected in a warm year at low discharge, pikeminnow would therefore appear to be the only fish predator of concern. These results are consistent with those of Ford and Brown (2001), who found numerous pikeminnow in both winter and summer surveys of the Lower Tuolumne River, but found smallmouth bass in low numbers except during summer months and found striped bass in only 1 year of 8, and also in very low numbers.

In the absence of quantitative data on the predation rates of pikeminnow, any evaluation of their impact on juvenile populations is speculative. But the potential for pikeminnow to concentrate at the base of the dam during emigration must be considered a negative factor in the emigration of juvenile salmonids in the Lower Yuba River, especially considering that spring-run chinook salmon would nearly all spawn above Daguerre Point Dam and their numbers are quite low. In addition, anecdotal accounts of pikeminnow and striped bass feeding at the base of the dam are probably reliable, but they offer no help in quantifying the significance (if any) of such predation.

- Absolute passage restriction for rearing and emigrating juvenile chinook and steelhead.

Juvenile chinook salmon and steelhead passing over the dam are blocked from returning upstream. In years when outflows are adequate to ensure low temperature conditions in reaches downstream of the dam, this is not necessarily a problem. If emigrating juveniles encounter warm temperatures, however, their ability to pass the dam and return to lower temperature conditions pending higher flows is eliminated by the dam. There are no data to establish the importance of such behavior to emigrating juveniles, or even to establish that juveniles in fact respond to higher downstream temperatures by returning upstream. Given that spring-run juveniles are likely to emigrate from March through June, with a majority out of the system before June, adverse temperature effects would generally be limited to the infrequent months of low flow and high temperature that are generally associated with drought.

There are also data which suggest that juvenile chinook salmon may be well-adapted to temperatures in the range they might experience in the Lower Yuba River below Daguerre Point Dam. Maslin et. al. (1999), for example, document juvenile chinook salmon rearing in a number of tributaries of the Sacramento River, including small tributaries on both the east and west sides of the SacramentoValley. Maslin et. al. (1999) also report that juveniles rearing in these tributaries were larger and in better condition that those collected from the mainstem river. Some of these streams have ephemeral flow; that is, they dry up in the summer. Water temperatures at their confluence with the Sacramento River would likely be higher than those in the Daguerre Reach of the Lower Yuba River, which has relatively higher flow from a reservoir source. In addition, Sommer et al (2000) document successful salmon and steelhead juvenile rearing in the Yolo Bypass, noting that juveniles grow faster in the Bypass than in the mainstem river, perhaps because temperatures in the Bypass were higher than those in the mainstem river, there is greater food supply in the Bypass and/or lower flow velocities in the Bypass reduce energy expenditure. In short, there is indirect evidence that juvenile rearing in the reach between Daguerre Point Dam and Marysville is not inherently detrimental and may be beneficial. The inability of juveniles to return to upstream habitats should not necessarily be considered detrimental.

However, for juvenile steelhead rearing downstream of Daguerre Point Dam, an inability to return to upstream habitats during warmer months could have a number of potential adverse consequences. First, in very dry years, when temperatures below Daguerre Point Dam might exceed 75°F (CDFG 1991), rearing juveniles could experience loss of condition unless food were, in fact, more abundant to offset energy losses due to high rates of metabolism. Steelhead might also experience temperature-induced mortality at higher modeled temperatures. Second, downstream-rearing juveniles would be subject to predation by warm water predators, which become increasingly active as temperatures exceed 65° F (Moyle 2002). Juveniles seeking to move into upstream habitat would also be subject to increased predation in the pool below the dam.

3.4 Conclusions regarding the effects of Daguerre Point Dam on salmonids in the Lower Yuba River

All of the conclusions below are based on the limited data sets currently available. These data sets allow some inferences related to passage issues, but there are no quantitative behavioral studies to confirm or falsify these inferences. The conclusions below are therefore based on data available and generally accepted understanding of salmon and steelhead life history and behavior.

Fall-run Chinook Salmon

The effects of Daguerre Point Dam on fall-run chinook salmon passage during spawning migrations appear to be minimal based on the typical flow ranges shown for the Daguerre Reach (Tables 4, 14) , but there may be delay associated with high flows during the early migration period of August through December. Passage delay may reduce the percentage of the spawning population reaching the upstream reaches of the river. In this upstream area, temperatures are typically lower and within reported suitable ranges for spawning and survival of early life stages. In addition flow conditions and physical river morphologic features are more diverse and more favorable to spawning, egg incubation, and juvenile rearing than in reaches downstream of Daguerre Point Dam. These passage restrictions may not have population level effects when escapement is high, because in such years available and suitable spawning habitat appears to be saturated. In years when escapements are low and ocean rearing conditions are poor, failure to reach better habitat in the upstream reaches may adversely affect populations through lowered reproductive success.

Delayed passage can also have an adverse effect on the condition of fall-run chinook salmon, both as a result of some injury at the dam and more importantly as a result of energy depletion during the passage delay. The effects of delayed passage on condition have been extensively studied in other rivers, but the mechanisms for delay and adverse impacts in these other systems are frequently different from those occurring at Daguerre Point Dam. For example, studies in the Columbia River Basin (such as Knapp 1992) cite spawning migration delay as a potential factor affecting salmon spawning success, but in this system delay often occurs at multiple sites in a 500 to 800 mile spawning migration. In the Columbia system, major issues for downstream passage of juveniles are avoidance of passage through turbines and navigation locks; these are not issues at Daguerre Point Dam. Thus, the consequences of adult delay, injury during spawning and juvenile disorientation during passage over the Daguerre Point Dam may be significantly different from those in other river systems. Beyond noting that other studies have found impacts related to delay, it is probably not valid to speculate that similar impacts are occurring in the Lower Yuba River.

Spring-run Chinook Salmon and Steelhead

There is little doubt that passage of spring-run chinook salmon and steelhead is delayed by high flows which limit the functionality of the existing ladders and the ability of fish to locate them or pass through them. The ladders will, in fact, be closed at times when spring-run chinook salmon and steelhead are migrating to spawn.

In years when these delays are extended, they probably have an adverse impact on the condition of adult spring-run chinook salmon. It is hypothesized that some spring-run chinook salmon are impacted to the extent that they do not gain access to upstream spawning habitat or are in poor spawning condition when they do reach this habitat after prolonged delay. However, USFWS 2001 spring-run chinook salmon redd counts above Daguerre Point Dam make it clear that some portion of these fish are able to utilize the fish ladders under suitable flow conditions and gain access to upstream habitats. Depending on the duration of delay due to the failure of fish ladders to function under high flows, there is a reasonable probability that spring-run chinook salmon attempting to ascend over the dam face will also sustain injuries that could impact health and spawning success. Steelhead may also be delayed in their spawning migration by the dam, although they may easily pass the dam at the beginning of their spawning run when flows in the Lower Yuba River are relatively low in October, November, and often in December. Juvenile rearing of steelhead and spring-run chinook salmon may also be adversely affected by the dam because juveniles rearing downstream of the dam may be stranded or left in sub-optimal-to-lethal water temperatures during the summer and fall.

Spring-run chinook salmon may also be adversely affected by large escapements of fall-run chinook salmon. The overlap of spring-run and fall-run spawning seasons (September- November and October-December, respectively), and the limitation of access to habitat that restricts both runs into the same spawning areas may result in fall-run chinook salmon superimposition on spring-run chinook salmon redds. The high spawner-to-redd ratios observed in the 2000 and 2001 surveys suggest that such redd superimposition could be a problem, especially for spring-run fish.

Effects on Spawning and Rearing Habitat

Daguerre Point Dam and the training dikes along the south shore of the Lower Yuba River that direct flows to it also clearly influence the quality of habitat upstream and downstream of the dam. The training dikes constrain flood flows to a relatively narrow floodplain, where high flows periodically scour riparian vegetation. The lack of large woody debris in the system may be related to the resulting immaturity of the riparian vegetation throughout the Lower Yuba River. Daguerre Point Dam also alters flow and sediment transport regimes upstream and downstream of the dam, reducing channel complexity. The relatively wide, shallow, flat river glides upstream and downstream of the dam probably do not represent optimum spawning and rearing conditions for salmonids.

4 4.0

EFFECTS OF PROJECT ALTERNATIVES

4.1 GENERAL

As described above, Daguerre Point Dam may affect spawning, rearing, and emigration via three primary mechanisms:

- Spawning habitat access, quantity and quality of habitat, and delay in accessing habitat

As discussed in Section 2.7, habitat upstream of Daguerre Point Dam, especially habitat for spring-run chinook salmon and steelhead, is of better quality than downstream habitat in terms of water temperature, stream gradient, and complexity. Water temperature is probably not a problem in winter and early spring, but may be a problem throughout the warmer months, when steelhead and spring-run chinook salmon would historically have utilized cool-water habitat upstream of Parks Bar. Daguerre Point Dam may reduce, under certain flow conditions, the number of salmonids able to access the remaining cool-water habitat between Daguerre Point Dam and Englebright Dam. Additionally, the dam and training dikes on the south side of the river may reduce the extent and quality of spawning habitat in the reach from Long Bar to the dam.

The dam also delays upstream migration, particularly when flows are high. Delay may result in loss of condition and injury associated with efforts to pass over the dam face. Prolonged delay may cause some fish (primarily fall-run chinook salmon) to spawn or rear in less favorable habitat downstream from the dam.

- Predation

The dam may affect predation on juvenile salmonids in two ways. First, pikeminnow may concentrate in the pool below the dam and effectively prey on disoriented juvenile salmonids passing over the dam face. Second, to the extent that the presence of the dam and its associated training dikes to the south of the river reduce riverbed physical habitat complexity and therefore cover, predation on juvenile salmonids may be enhanced.

- Juvenile rearing and emigration

In the reach from Long Bar to the dam and from the dam downstream, the dam may contribute to poor juvenile rearing conditions downstream. This portion of the Parks Bar Reach shares some characteristics with the Daguerre Reach, including fewer riffles, relative lack of deep pools, and wide, shallow glides with relatively uniform channel cross-sections. Juvenile salmonids do not have the swimming speed and/or leaping ability to pass upstream via ladders, which are designed to function for adults. Therefore the dam also prevents rearing juvenile steelhead and spring-run chinook salmon from regaining access to better quality habitat upstream of the dam during the warmer months, although there is no direct evidence that this adversely affects rearing or survival. The potential benefits of the various passage alternatives being considered relate to how each alternative might affect the above factors. These benefits and impacts will be evaluated in detail, based on detailed alternative designs, in the project EIR/EIS. The following discussion is intended to provide a conceptual basis for this analysis of benefits and impacts.

4.2 CLASSIFICATION OF ALTERNATIVES

There are a number of specific alternatives, and more may be formulated during the planning process. In general, these alternatives fall into two classes:

- New or reconfigured passage facilities
- Dam alteration or removal

There may be subtle differences between specific alternatives in each classification. These cannot be evaluated in detail until designs have been completed. But the range of potential benefits and impacts may be generally described for each class, in terms of how each class of alternative may conceptually affect spawning, egg incubation, rearing, and emigration of salmonids.

4.3 NEW OR RECONFIGURED PASSAGE FACILITIES

Passage facilities may take a number of forms -- new conventional fish ladders, downstream weir/step facilities, a notched dam and upstream ladder, or fish elevators, alternatives initially suggested in a preliminary project report (ACOE 2001). It may be assumed that all new or reconfigured passage facilities would be designed to improve upstream passage under all but the highest flow conditions. The benefits and impacts of this class of alternatives would generally be limited (Table 16).

To the extent that the Lower Yuba River is habitat limited, particularly in years when escapement is good, the probable benefits of new or reconfigured passage facilities may be somewhat offset by indirect impacts. Spring-run chinook salmon, spawning in September through November (CDFG 1991) might be adversely affected by alternatives that merely improve passage without creating additional spawning area. For such alternatives, improved passage of fall-run chinook salmon, which spawning in October through January, could result in greater superimposition of fall-run spawning on spring-run salmon spawning redds.

4.4 DAM ALTERATION OR REMOVAL ALTERNATIVES

Dam removal, notching a section of the dam, and or constructing an alternative channel for the river on the south side of the existing abutment could alter the physical structure of the channel both upstream and downstream. Conceptual benefits and impacts of such alternatives are outlined on Table 17.

Table 16. Conceptual benefits and impacts for new or reconfigured passage facilities (*e.g.* new fish ladders, etc).

Benefit/Impact Category	Benefits	Impacts
Spawning habitat		
Access	Improved, especially for spring-run chinook salmon and steelhead and during periods of high flows	In years when escapement is high, fall-run chinook salmon may swamp spawning habitat in the upstream reaches.
Quantity	No change	No change
Quality	No change	No change
Access Delay	Reduced delay for all adult salmonids. Reduced potential for condition loss and injury associated with delay.	None anticipated
Predation on juveniles		
In pool below the dam	Benefits accrue only if the pool below the dam is eliminated	If improved passage results in more upstream spawning, then a greater proportion of juvenile salmonids would be subject to predation at the pool below the dam.
In river	No change	If improved passage results in more upstream spawning and rearing, avian and fish predators may be more successful in this reach.
Juvenile rearing and emigration		
Rearing habitat	No change	No change
Emigration	No change	No change, continued injury or predation losses

The site-specific effects of dam alteration or removal on salmonids and their habitats are difficult to predict, as they would depend on the particulars of alternative design and on flow regimes in years following removal. Table 16 is based on some assumptions about the various dam alteration or removal alternatives.

Table 17. Conceptual benefits and impacts for dam alteration and removal alternatives (*e.g.* dam removal, bypass channel, etc.).

Benefit/Impact Category	Benefits	Impacts

Spawning habitat		
Access	Improved access	In years when escapement is high, fall-run chinook salmon may swamp spawning habitat in the upstream reaches.
Quantity	Assuming sediment removal prior to dam modification, about 2.5 to 3.0 miles of improved habitat would be created upstream from the dam. Altered sediment and flow regimes would also change habitat characteristics downstream.	Potential short-term impacts during the period when the river was being reconfigured during construction. May be reduced by implementation of sediment control BMP's.
Quality	Higher river gradient would result in better quality spawning and egg incubation habitat. Slightly improved water temperatures below Long Bar.	Potential short-term impacts during the period when the river was being reconfigured.
Access Delay	Elimination of delay, especially for spring-run chinook salmon.	Potential short-term impacts to passage during dam alteration or demolition (These impacts would vary depending on construction timing, but there are salmonids moving upstream or downstream at all times during the year.)
Predation on juveniles		
In pool below the dam	Eliminated	None anticipated
In river	Potential reduction in predation if river reconfiguration resulted in more pool and riffle habitats.	Probable increase in the ability of pikeminnow to move, by removing the dam which may impede their passage during high flows.
Juvenile rearing and emigration		
Rearing habitat	Probable increase in preferred pool and riffle habitats, upstream and downstream of the dam for 2-3 miles or more.	Short-term impacts during river reconfiguration.
Emigration	Eliminates the dam as a factor in emigration as well as habitat selection during instream rearing for steelhead and spring run chinook salmon.	Short-term impacts during river reconfiguration. Potential for stranding juveniles if a second channel is constructed around the dam and juveniles become pass this channel and pass downstream, becoming trapped between this channel entrance and the dam.

4.5 CONCLUSIONS REGARDING CONCEPTUAL BENEFITS AND IMPACTS OF DIFFERENT ALTERNATIVES

4.5.1 NEW OR RECONFIGURED PASSAGE FACILITIES

Although fall-run chinook salmon are delayed in their upstream spawning run by the design of the existing fish ladders, the high percentage of fish spawning in upstream reaches clearly demonstrates that the existing ladders provide some passage. In years of good escapement, current passage rates may even saturate upstream spawning habitat for fall-run salmon.

New or reconfigured passage facilities would benefit spring-run chinook salmon and steelhead, particularly in years when high flows render the existing fish ladders impassible. Improved passage for fall-run chinook salmon may have the unintended effect of redd superimposition that impacts redds of spring-run salmon. Fish ladders do not alter the total amount of habitat available or habitat conditions, and any loss of spring-run redds due to higher numbers of fall-run chinook salmon reaching upstream spawning areas would be potentially detrimental.

4.5.2 DAM ALTERATION OR REMOVAL ALTERNATIVES

Dam alteration or removal alternatives, including the construction of a bypass channel, have the potential to both improve passage and increase the area and quality of spawning, incubation, and rearing habitats. For spring-run chinook salmon, these benefits may be considered significant if the habitat created resembles that in the Rose Bar Reach. Dam alteration or removal alternatives also have potential adverse short-term impacts and, if this approach to improving passage is selected, these short-term impacts should be minimized through project design and construction scheduling.

5 5.0 OTHER FACTORS AFFECTING PASSAGE IMPROVEMENT BENEFITS

5.1 MERCURY

There are probably significant deposits of elemental and methyl mercury in the sediments trapped behind Daguerre Point Dam (CDFG 1991; USGS personal communication), remnants of historic hydraulic mining and gold processing. These deposits could be mobilized during dam removal. Their potential for adverse impacts on salmonids (and domestic and agricultural water quality) would need to be considered and addressed in any alternative involving dam alteration. Sediment removal prior to dam removal would probably address this issue. Studies of mercury contamination and possible best management practices to reduce impacts of construction of alternatives are pending.

5.2 OTHER BARRIERS TO FISH MIGRATION

CDFG (1991) evaluated barriers to fish migration both upstream and downstream from Daguerre Point Dam under relatively low flow conditions (mean monthly flows of 461cfs in October and 684 cfs in December). Under current sediment erosion, transport, and deposition regimes, they found no functional barriers to migration. Water depths across riffles, runs, and glides were adequate for salmon to reach all areas of the river below Englebright Dam.

Changes in sediment erosion, transport, and deposition associated with dam removal or modification alternatives could in the short term alter depositional regimes downstream from the dam at low flows and create barriers where none now exist. These could be monitored during the initial period of the project to ensure that passage was not affected by the changed sedimentation conditions.

5.3 UPSTREAM MOVEMENT OF NON-NATIVE PREDATORS

CDFG (1991) snorkel and electrofishing surveys of the Lower Yuba River found very few smallmouth bass and no striped bass in the dry and warm periods of May of 1987 or 1988. Such warm water predators are not likely to be present in the river in great numbers at any time (CDFG 1991). In addition, water temperatures upstream of Daguerre Point Dam are under almost all conditions less-than-favorable for these warm water predators when juvenile salmon are present (Table 14). Neither striped bass nor smallmouth bass are commonly found in rapidly flowing, clear, low water temperature variable rivers (Hassler 1988, Moyle 2002). In the Central Valley, they are often found in mainstem rivers and in the lower reaches of tributary rivers (Moyle 2002). Striped bass spawning starts in April and peaks in May and early June. No spawning occurs until temperatures reach at least 57°F (Moyle 2002). Optimum spawning temperature appears to be 59°F to 68°F (Moyle 2002). Finally, smallmouth bass are ambush predators, relying on concealment along rip-rap or vegetated river margins for cover. Smallmouth bass prefer clear stream and rivers with abundant cover and cool (68°F to 80°F) summer temperatures (Moyle 2002). Smallmouth bass populations are rarely established where water temperatures do not exceed 66°F in the summer for extended periods and most smallmouth populations in California water seem to be in places where summer temperatures are typically 70°F to 72°F (Moyle 2002). The Lower Yuba River does not have these habitat conditions, except in the downstream reaches (ENTRIX 2002). The potential for significant upstream migration of such non-native predators, and the resulting potential for significant predation in upstream reaches as a result of barrier removal, may be considered insignificant.

6 6.0 FLOW MANAGEMENT UPSTREAM OF DAGUERRE POINT DAM

The initial question regarding potential delay in emigration, presupposes that Daguerre Point Dam may have the effect of delaying emigration. Given the configuration of the dam, which provides for flows to pass unobstructed over the entire face of the dam, there does not appear to be any physical mechanism associated with dam operation that would necessarily result in emigration delay. Juvenile salmonids approaching Daguerre Point Dam face no physical obstacle to downstream migration at the dam itself; even under low flow conditions, there is adequate flow for juveniles to pass over the dam. There is no evidence in the literature that juvenile salmonid emigration is, in fact, delayed by Daguerre Point Dam. CDFG (1991) reports virtually no juvenile chinook salmon in the Narrows Reach during either May of 1987 or May of 1988. In the May 1987 electrofishing surveys, juvenile chinook salmon were generally found in reaches below the Narrows (Figure 2.2):

- Garcia Gravel Pit Reach: 387 fish
- Daguerre Point Dam Reach: 82 fish
- Simpson Lane Reach: 352 fish

In May 1988 snorkeling surveys, the distribution of juveniles was skewed towards the Garcia Gravel Pit Reach (Figure 2.2), although these fish were also distributed in the lower reaches:

- Garcia Gravel Pit Reach: 3,108 fish
- Daguerre Point Dam Reach: 611 fish
- Simpson Lane Reach: 587 fish

These data for two dry years show juveniles in all reaches, with some apparent holding of juveniles in the upstream Garcia Gravel Pit Reach (which extends to Daguerre Point Dam) in May. If the May 1988 data are correct and juveniles in the Garcia Gravel Pit Reach were delaying emigration, this may have more to do with low flows and higher temperatures than a physical passage effect of Daguerre Point Dam. Juvenile salmonids may suffer higher predation from avian predators in shallow water. Implementation of CDFG (1991) flow/temperature recommendations would also address any flow issue. Given escapement for 1986 and 1987 of about 19,000 and 18,000 fall-run chinook salmon (respectively), however, the numbers of juveniles identified in these two surveys represent a miniscule percentage of the expected juvenile population. Either the CDFG 1987 and 1988 surveys had poor detection rates, or a majority of the juvenile salmon had already left the system by the time the surveys were conducted. The latter conclusion would not be unexpected. Williams (2001) notes that most juvenile salmon in the

American River are "gone by mid-May" and that this trend is confirmed by both trap and seine data. In the American River, some salmon juveniles are known to rear as late as mid-July as well (Williams 2001).

The low numbers of salmon juveniles observed in CDFG 1987 and 1988 surveys may therefore be an indication of a normal or even early emigration, rather than delayed emigration. Rotary screw trap studies currently underway in the Yuba River may resolve this issue in the future.

The various passage alternatives could alter the physical habitat of the Lower Yuba River in ways that would logically have indirect effects on downstream emigration. Juvenile salmonid emigration in the Yuba River occurs in the winter and spring (CDFG 1991):

- Fall-run chinook salmon

Fry	January - March
Smolts	April - June

- Spring-run chinook salmon — Nov - June
- Steelhead — March - June

Irrigation facilities may affect juvenile emigration and these effects may change, depending on the alternative selected. Surface water diversion facilities upstream of the dam divert a maximum combined rate of 1,350 cfs during the irrigation season from April to October. Brown's Valley Irrigation Diversion canal is located on the north bank approximately 0.8 miles upstream of the Daguerre Point Dam and diverts up to 100 cfs. Hallwood-Codura Irrigation Diversion is located on the north bank adjacent to Daguerre Point Dam and diverts a maximum of 650 cfs. A fixed V-shaped fish screen is located within the diversion canal, 0.25 miles downstream of the intake. South Yuba Brophy Irrigation District is located on the south side of the river about 0.15 miles upstream of Daguerre Point Dam. Upstream of the diversion, a 450-foot gabion permeable weir prevents adult fish from being entrained but allows juveniles to pass through. A maximum of 600 cfs can be diverted.

From January through March, irrigation facilities are not generally in operation, as indicated by similar or higher flows at Marysville than upstream at Smartville (Table 4). River flows are therefore relatively high and consistent from Englebright Dam to Marysville. As the spring irrigation season begins, however, an increasing percentage of discharge from Englebright Dam is diverted from the river, and in dry years such as 1994 flows downstream at Marysville are often 50 percent or less than discharges from Englebright Dam. When irrigation diversions constitute a significant portion of the mainstem flow, the operation of irrigation diversions may temporarily divert emigrating salmonids from the mainstem channel, even though the diversions are screened.

Fish ladder alternatives, the notch alternative, and the bypass channel alternative would not necessarily mandate changes to the existing and effective diversion structures between Parks Bar and Daguerre Point Dam, because there would be no change in streambed or water surface elevations associated with these simple passage-improvement alternatives. The significant physical changes to the river associated dam removal or lowering alternatives could mandate such changes and these new structures would reflect best available control technology to further reduce diversion impacts on emigrating salmonids.

The second element of this issue is the potential for adverse water temperature impacts on emigrating juveniles. As noted in the discussion of mean monthly flows and temperatures, high flows are more likely during the emigration periods from January through June than are low flows, and implementation of the flow recommendations from CDFG 1991 would provide for temperatures below 60°F during all but the month of June. CDFG (1991) also clearly notes that water temperatures during summer months are generally lower as a result of reservoir storage and releases than they would have been under historic conditions. Although Daguerre Point Dam may have the effect of reducing flow velocities in the reach behind the dam where sediment creates a broad and shallow river channel, water temperatures during emigration would not appear to be a problem upstream from the dam, provided that CDFG (1991) flow recommendations are implemented.

The third element of this issue is the potential for increased predation related to emigration delay. Assuming a fixed number of predators in any given year, delayed emigration would be expected to increase the exposure of emigrating (and rearing) salmonids to predation. Given that the dominant piscivores in the system upstream from Daguerre Point Dam are birds such as mergansers and herons, pikeminnow, and (perhaps) river otters, juvenile salmonids are currently subject to predation. The shallow low gradient pools upstream of Daguerre Point Dam may expose juveniles to higher levels of in-river predation than would occur if a more natural stream gradient and channel configuration were restored in the reach above the dam. Whether such reductions in predation would be significant in terms of overall survival of juveniles during their emigration is unknown, although Maslin et al. (1999) suggests that prolonged rearing in tributaries may benefit salmonids.

7 7.0

SUMMARY OF FINDINGS

This analysis has been focused on the various hypotheses regarding the effects of Daguerre Point Dam on salmonids. Conclusions related to these hypotheses have been based on analysis of existing data and on inferences drawn from comparisons of the physical conditions of the Lower Yuba River to the habitat requirements of chinook salmon and steelhead.

Hypothesis: The dam, with the existing fish ladders, blocks or substantially delays upstream passage of salmonids during their spawning migration, resulting in underutilization of upstream habitats.

Our review confirms that Daguerre Point Dam blocks upstream passage of both fall-run and spring-run chinook salmon and delays passage to some extent when flows exceed about 2000 cfs. The fish ladders clearly function at flows below this, as evidenced by the substantial spawning activity above the dam. A majority of fall-run chinook salmon spawning occurs upstream of the dam and there is no indication that the upstream habitat is underutilized. All spring-run chinook salmon spawning occurs upstream of the dam, suggesting that spring-run chinook salmon are not diverted to lower elevation habitats downstream of the dam. There is evidence that upstream habitat may be over-utilized and that redd superimposition may be a problem.

Hypothesis: During passage delay, adults may experience losses in condition due to temperature and injury. This may affect spawning success.

Given CDFG (1991) temperature modeling, spawning migration delay associated with the dam would not appear to expose salmon and steelhead to adverse temperature effects. Higher water temperatures below the dam are associated with low flows, when the ladders are most functional. Water temperatures below the dam during the spring-run chinook salmon spawning migration are within the preferred range except in dry years, when flows are low and access via the existing ladders is feasible.

There is no direct evidence that holding below the dam when the ladders are not fully functional affects the condition of salmon during their migration, except that repeated attempts to pass over the dam probably results in injury from contact with the rough concrete surface of the dam face. Such injury may result in increased susceptibility to disease and may affect spawning success.

Hypothesis: The large plunge pool at the base of the dam allows predatory fish to concentrate and prey effectively on emigrating juvenile salmonids.

There is no substantial evidence of predation on emigrating juvenile salmon by warm water fish, and temperature and habitat conditions in the Lower Yuba River are not conducive to the establishment of significant populations of such fish except perhaps in the Marysville area. There are anecdotal reports of predation by striped bass and pikeminnow at the base of the dam and salmon passing over the dam are likely to be disoriented, and thus susceptible to predation. Pikeminnow, which are found both above and below the dam, are effective predators on disoriented juvenile salmon. The dam probably therefore increases localized predation on juvenile salmonids. There are no data to indicate whether such predation is significant, whether predation at the dam is offset by lower predation rates downstream, or even what percentage of juvenile salmonids are taken by predators.

Hypothesis: If emigrating salmon and steelhead juveniles encounter high water temperatures in the reach below Daguerre Point Dam, they cannot return to the lower-temperature habitat upstream because their passage is blocked by the dam and difficulty finding ladder entrances.

There is no indication that juvenile fall-run or spring-run chinook salmon are attempting to pass over fish ladders as a result of encountering warm water temperatures in downstream locations and recent data from Maslin et al. (1999) and Sommer et. al. (2000) suggest that juveniles may thrive in moderately warmer waters, provided nutrients are available to support their high metabolic rates that these temperatures. There is some possibility that warm water conditions downstream of the dam may adversely affect steelhead, which rear inland for extended periods, but there are no data to confirm or falsify this hypothesis.

Hypothesis: The dam alters sediment erosion, transport, and deposition regimes in the river, both upstream and downstream, and affects the amount and quality of spawning habitats.

Entrix field observations in 2002 confirm those of CDFG (1991). The dam and its associated training dikes affect channel slope and channel complexity. This effect is compounded by the distribution of spoil from historic hydraulic mining. By flattening the channel slope in the reach directly influenced by Daguerre Point Dam (upstream and downstream), the dam reduces the availability of riffle-pool complexes, which provide preferred spawning conditions (gravels at the head of riffles) and rearing conditions (both in-gravel rearing and rearing of emergent juveniles. The training dikes confine the river to a relatively narrow floodplain and constrained high flows scour vegetation and the smaller fractions of available sediments from the upper portions of the Parks Bar Reach, creating long sections of river runs characterized by a uniform large cobble/small boulder substrate. In these reaches, salmon do not have access to spawning gravels except along the margins of the channel.

8 8.0

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Attachment 1
USFWS GPS Redd Survey Coordinates

Yuba River 2000 Fall-run Chinook Salmon Redd Count by Jones and Stokes

Reach	Count	Associated 2001 USFWS Redd Number	WP ID	Notes
Rose Bar	10			US of Rose Bar
Rose Bar	1			US of Rose Bar
Rose Bar	3			US of Rose Bar
Rose Bar	1			US of Rose Bar
Rose Bar	1			US of Rose Bar
Rose Bar	2	1	441,442	
Rose Bar	1			
Rose Bar	1			
Rose Bar	1			
Rose Bar	1			
Rose Bar	5	2	443,444	
Rose Bar	1			
Rose Bar	25	3	446	
Rose Bar	1	4	445,447	
Rose Bar	1	4	445,447	
Rose Bar	1	4	445,447	
Rose Bar	2	4	445,447	
Rose Bar	20	5-7	448, 449, 451, 452, 453, 454	
Rose Bar	76	8	309,32	U.C. Property
Rose Bar	6	9	310,311	
Rose Bar	1	10	312,313	
Rose Bar	9	11	314,315	
Rose Bar	7			
Rose Bar	30	12	316,317	
Rose Bar	20	13	318,319	
Rose Bar	30	14-15	320,321,322	
Rose Bar	6			
Rose Bar	1	16	323	
Rose Bar	1			
Rose Bar	30	17	324	
Rose Bar	10	18	325,326	Hiway 20
Parks Bar	10	21	332,333,334	
Parks Bar	6			
Parks Bar	3	22	335,336	
Parks Bar	8	23	337,338	
Parks Bar	11	25	341,342	
Parks Bar	4	25	341,342	
Parks Bar	1	26	343,344	
Parks Bar	1	27	345,346	
Parks Bar	2			
Parks Bar	1	28	347	
Parks Bar	1	29	348	
Parks Bar	1	30	349	
Parks Bar	1	31	351,350	
Parks Bar	1	31	351,350	
Parks Bar	1	31	351,350	
Parks Bar	15	31	351,350	
Parks Bar	1	33	352,353	
Parks Bar	9	33	352,353	
Parks Bar	8	34	354	
Parks Bar	25			
Parks Bar	40	35	335,356	
Parks Bar	8	38	361	
Parks Bar	12	43	370,371,372	
Parks Bar	10			
Dauguerre	38	51	456,457	
Dauguerre	15	51.5	455	
Dauguerre	3	51.5	455	
Dauguerre	5			
Dauguerre	2	52	390,391	
Dauguerre	41	52	390,391	
Dauguerre	3	52	390,391	
Dauguerre	4	52	390,391	
Dauguerre	6	53	392,393	
Dauguerre	29	54	394,395	
Dauguerre	6	55	396,397	
Dauguerre	34	56	398,399	
Dauguerre	1	57	400,401	
Dauguerre	1	57	400,401	

Yuba River 2000 Fall-run Chinook Salmon Redd Count by Jones and Stokes

Reach	Count	Associated 2001 USFWS Redd Number	WP ID	Notes
Dauguerre	1	58	402,403	
Dauguerre	1	59	404,405	
Dauguerre	14	59	404,405	
Dauguerre	12	60	406,407	
Dauguerre	9	61	408,409	
Dauguerre	9			
Dauguerre	25	63	412,413	
Dauguerre	6	64	414,415	
Dauguerre	10	65	416,417	
Dauguerre	3	66	418,419	
Dauguerre	1	67	421,422	
Dauguerre	16	67	421,422	
Dauguerre	2	68	423,424	
Dauguerre	2	69	425,426	
Dauguerre	5	71	428,429	
Dauguerre	7	72	430,431	
Dauguerre	4	73	432,433,434	
Dauguerre	1	73	432,433,434	
Dauguerre	3	74	436,437,438	
Dauguerre	10	75	439,440	
Dauguerre	2			
Dauguerre	2			
Dauguerre	3			
Dauguerre	1	77	460	
Dauguerre	1	78	461,462	
Dauguerre	1	78	461,462	
Dauguerre	2	79	463,464	
Dauguerre	1	79	463,464	
Dauguerre	3	80	465,466	
Dauguerre	4	80	465,466	
Dauguerre	4	82	469	
Dauguerre	1	83	470,471	
Dauguerre	1	83	470,471	
Dauguerre	2			
Dauguerre	5			
Dauguerre	8	84	472,473	

Yuba River 2001 Spring-run Chinook Salmon Redd Count by USFWS

WP	EAST	NORTH	ERR	ELEV	ELEVM	Sp. Area	# redd	%super	Note
131	645483	4343981	9	245.9	75	1	8		
132	645524	4343962	7	247.2	75				
133	645587	4343914	7	252.8	77	2	100		
134	645815	4343856	9	264.8	81				
135	644613	4344060	8	272.5	83	3	0		
136	644404	4343833	32	258.8	79				
137	644322	4343680	10	246.1	75	4	25		
138	644380	4343157	9	173.5	53				
139	644252	4342704	9	175.1	53	5	3		
140	644140	4342552	25	176.0	54				
141	644018	4342520	7	191.9	58	6	15		
142	643894	4342512	7	202.3	62				
143	643164	4342553	5	164.1	50	7	3		
144	643038	4342529	5	165.0	50				
145	642779	4342461	0	170.1	52	8	3		
146	642599	4342510	12	170.0	52				
147	642321	4342655	15	165.3	50	9	14		
148	642244	4342702	5	156.6	48				
149	642055	4342770	11	153.0	47	10	4		
150	641661	4342436	9	167.8	51	11	10		
151	641648	4342337	9	166.3	51				
152	641602	4342192	8	163.1	50	12	2		
153	641475	4342155	8	163.8	50				
154	640855	4342312	0	164.1	50	13	3		
155	640786	4342342	8	159.9	49				
156	640064	4342515	10	176.8	54	14	4		
157	639838	4342548	10	165.9	51				
158	639767	4342564	8	153.5	47	15	3		
159	639646	4342571	7	143.2	44				
160	639412	4342476	9	142.5	43	16	5		
161	639302	4342480	7	134.0	41				
162	638011	4342907	11	143.3	44	17	4		
163	637916	4342887	11	142.7	43				
164	637799	4342823	11	143.6	44	18	5		
165	637664	4342732	8	157.7	48				
166	637468	4342436	8	134.0	41	19	3		
167	637423	4342357	10	129.7	40				
168	636603	4342177	7	135.0	41	20	10		
169	636517	4342103	7	129.7	40				
170	636497	4342099	7	129.0	39	21	12		
171	636165	4342012	6	126.8	39				
172	635947	4341915	6	123.3	38	22	3		
173	635794	4341868	9	119.1	36				
							239		

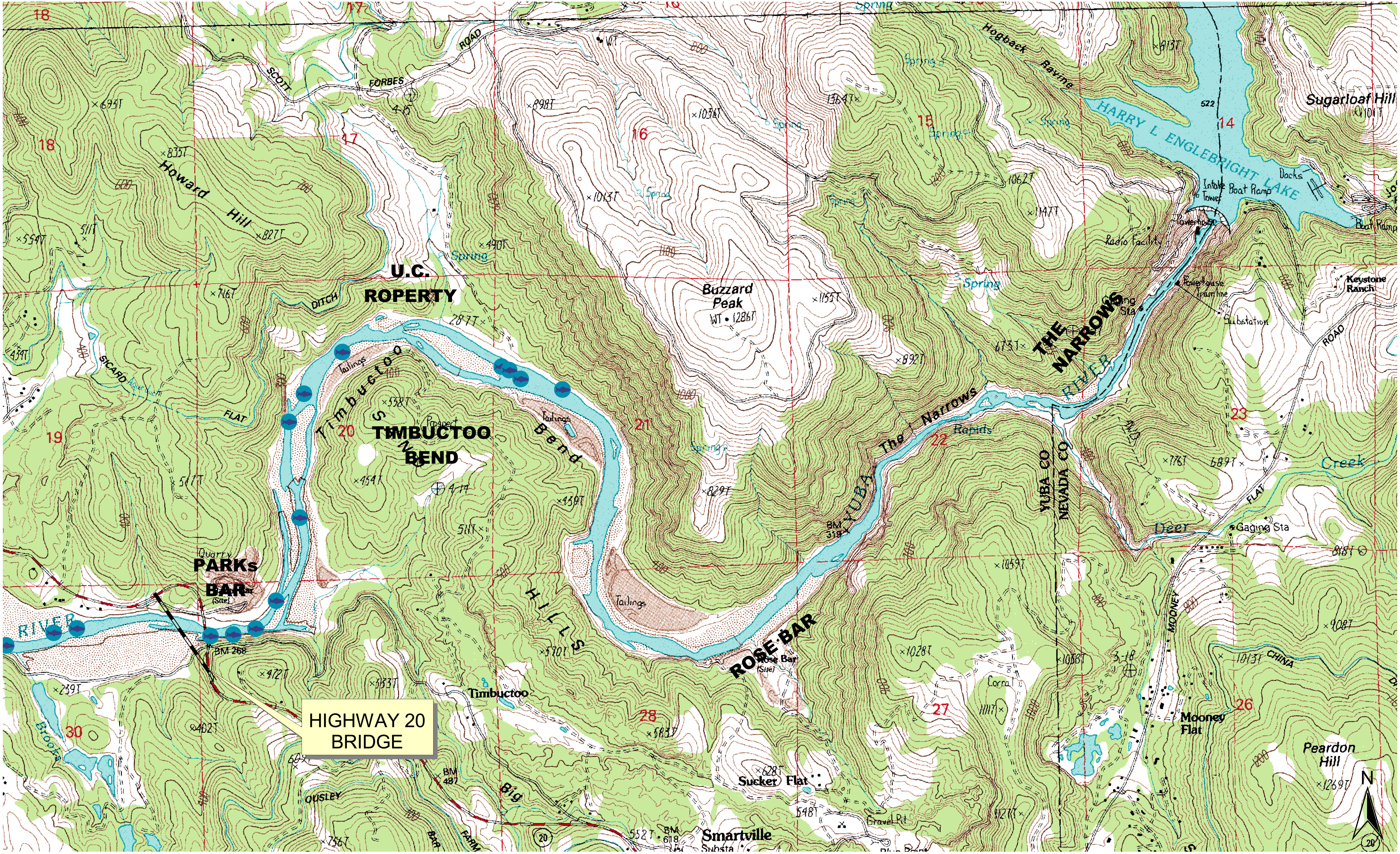
Yuba River 2001 Fall-run Chinook Salmon Redd Count by USFWS

Reach	Redd Number	No. of Redds	WP ID	% Superimposition	Notes
Rose Bar	1	15	441,442	0%	
Rose Bar	2	2	443,444	0%	
Rose Bar	3	1	446	0%	
Rose Bar	4	14	445,447	0%	
Rose Bar	5	11	448,449	0%	
Rose Bar	6	3	451,452,453	0%	
Rose Bar	7	24	453,454	20%	
Rose Bar	8	100	309,32	35%	>100, U.C. Property
Rose Bar	9	2	310,311	0%	10-20 old redds
Rose Bar	10	5	312,313	0%	
Rose Bar	11	6	314,315	0%	
Rose Bar	12	46	316,317	15%	
Rose Bar	13	13	318,319	0%	
Rose Bar	14	13	320	0%	
Rose Bar	15	6	321,322	0%	
Rose Bar	16	1	323	0%	
Rose Bar	17	1	324	0%	
Rose Bar	18	23	325,326	5%	Hiway 20
Rose Bar	19	5	327,328	10%	
Parks Bar	20	17	329,330,331	5%	
Parks Bar	21	7	332,333,334	10%	
Parks Bar	22	5	335,336	0%	
Parks Bar	23	7	337,338	5%	
Parks Bar	24	3	339,340	0%	
Parks Bar	25	26	341,342	10%	
Parks Bar	26	5	343,344	0%	
Parks Bar	27	3	345,346	0%	
Parks Bar	28	1	347	0%	
Parks Bar	29	3	348	20%	
Parks Bar	30	3	349,350	20%	
Parks Bar	31	36	351,350	20%	
Parks Bar	32	6		5%	
Parks Bar	33	45	352,353	15%	
Parks Bar	34	10	354	10%	
Parks Bar	35	6	335,356	0%	
Parks Bar	36	16	357,358	10%	
Parks Bar	37	17	359,360	5%	
Parks Bar	38	10	361	0%	
Parks Bar	39	6	362,363	25%	
Parks Bar	40	30	364,365	15%	
Parks Bar	41	3	366	10%	
Parks Bar	42	10	367,368	10%	
Parks Bar	43	25	370,371,372	20%	
Parks Bar	44	8	373,374	0%	
Parks Bar	45	2	375	0%	
Parks Bar	46	7	376,377,378	0%	
Parks Bar	47	1	379	0%	
Parks Bar	48	24	380,381	5%	

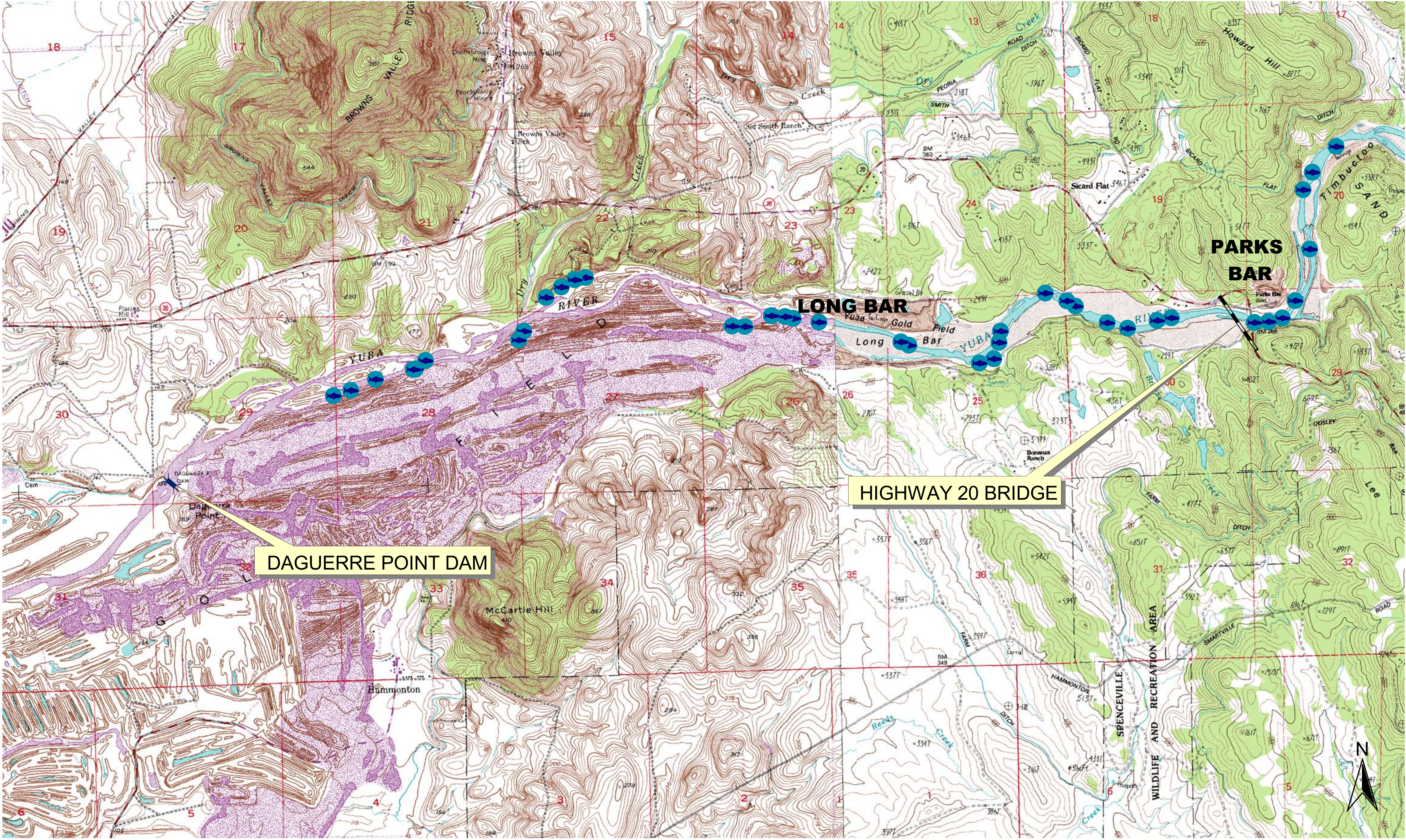
Yuba River 2001 Fall-run Chinook Salmon Redd Count by USFWS

Parks Bar	49	12	382,384	0%	
Parks Bar	50	6	308	0%	
Dauguerre	51	25	456,457	20%	
Dauguerre	51.5	2	455	0%	
Dauguerre	52	75	390,391	50%	>75 redds
Dauguerre	53	70	392,393	15%	
Dauguerre	54	25	394,395	5%	
Dauguerre	55	14	396,397	5%	
Dauguerre	56	51	398,399	5%	
Dauguerre	57	18	400,401	5%	
Dauguerre	58	4	402,403	0%	
Dauguerre	59	19	404,405	5%	
Dauguerre	60	24	406,407	5%	
Dauguerre	61	32	408,409	10%	
Dauguerre	62	8	410,411	5%	
Dauguerre	63	24	412,413	5%	
Dauguerre	64	30	414,415	5%	
Dauguerre	65	20	416,417	10%	
Dauguerre	66	3	418,419	0%	
Dauguerre	67	40	421,422	10%	
Dauguerre	68	16	423,424	5%	
Dauguerre	69	9	425,426	10%	
Dauguerre	70	6	427	0%	
Dauguerre	71	25	428,429	25%	
Dauguerre	72	15	430,431	0%	
Dauguerre	73	22	432,433,434	0%	
Dauguerre	74	34	436,437,438	5%	
Dauguerre	75	30	439,440	5%	
Dauguerre	76	18	458,459	10%	
Dauguerre	77	3	460	0%	
Dauguerre	78	4	461,462	0%	
Dauguerre	79	3	463,464	0%	
Dauguerre	80	6	465,466	20%	
Dauguerre	81	6	467,468	25%	
Dauguerre	82	1	469	0%	
Dauguerre	83	3	470,471	0%	
Dauguerre	84	3	472,473	0%	
Dauguerre	85	3	474,475	0%	

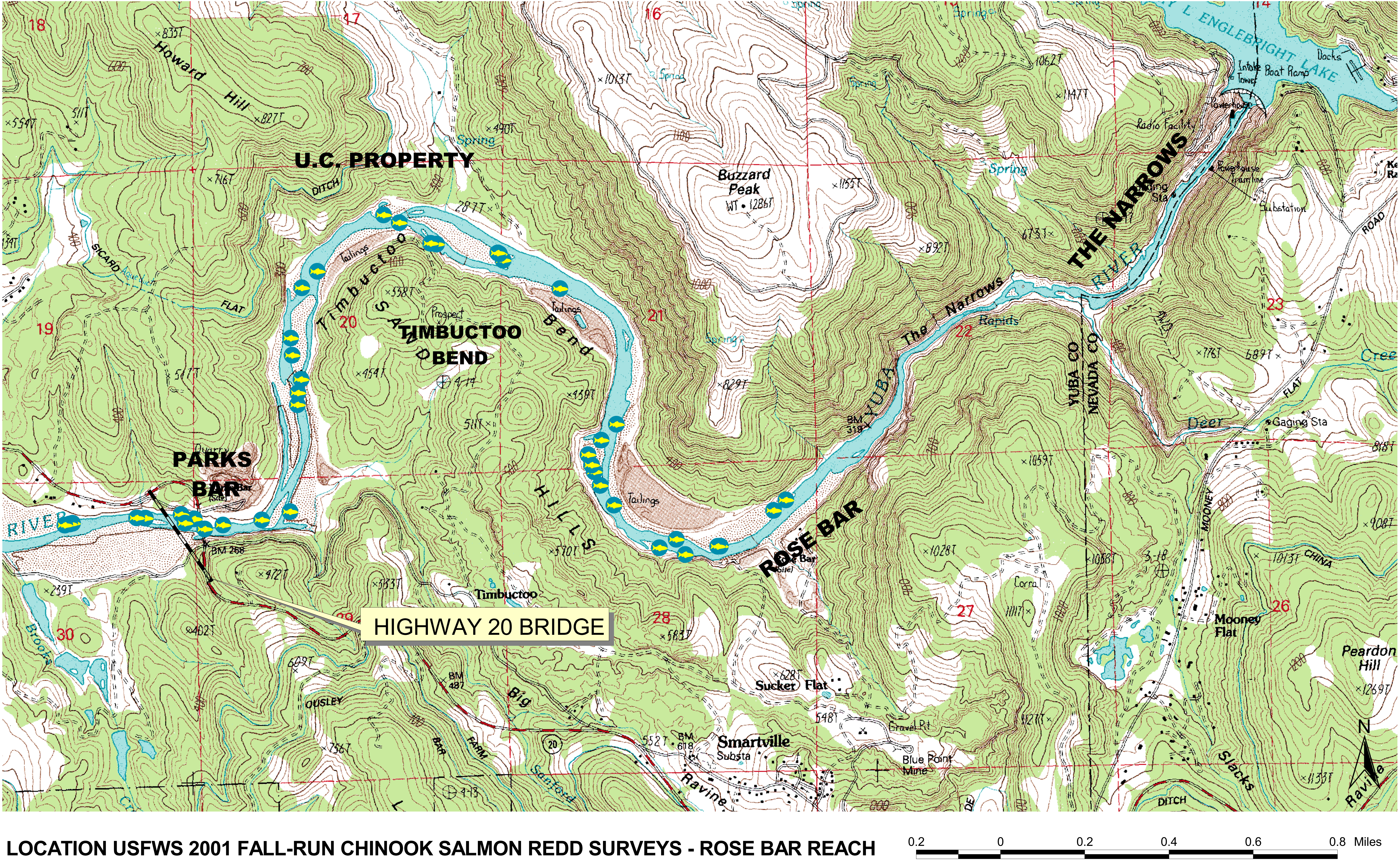
Attachment 2
ENTRIX Maps Prepared from USFWS Redd Survey Coordinates



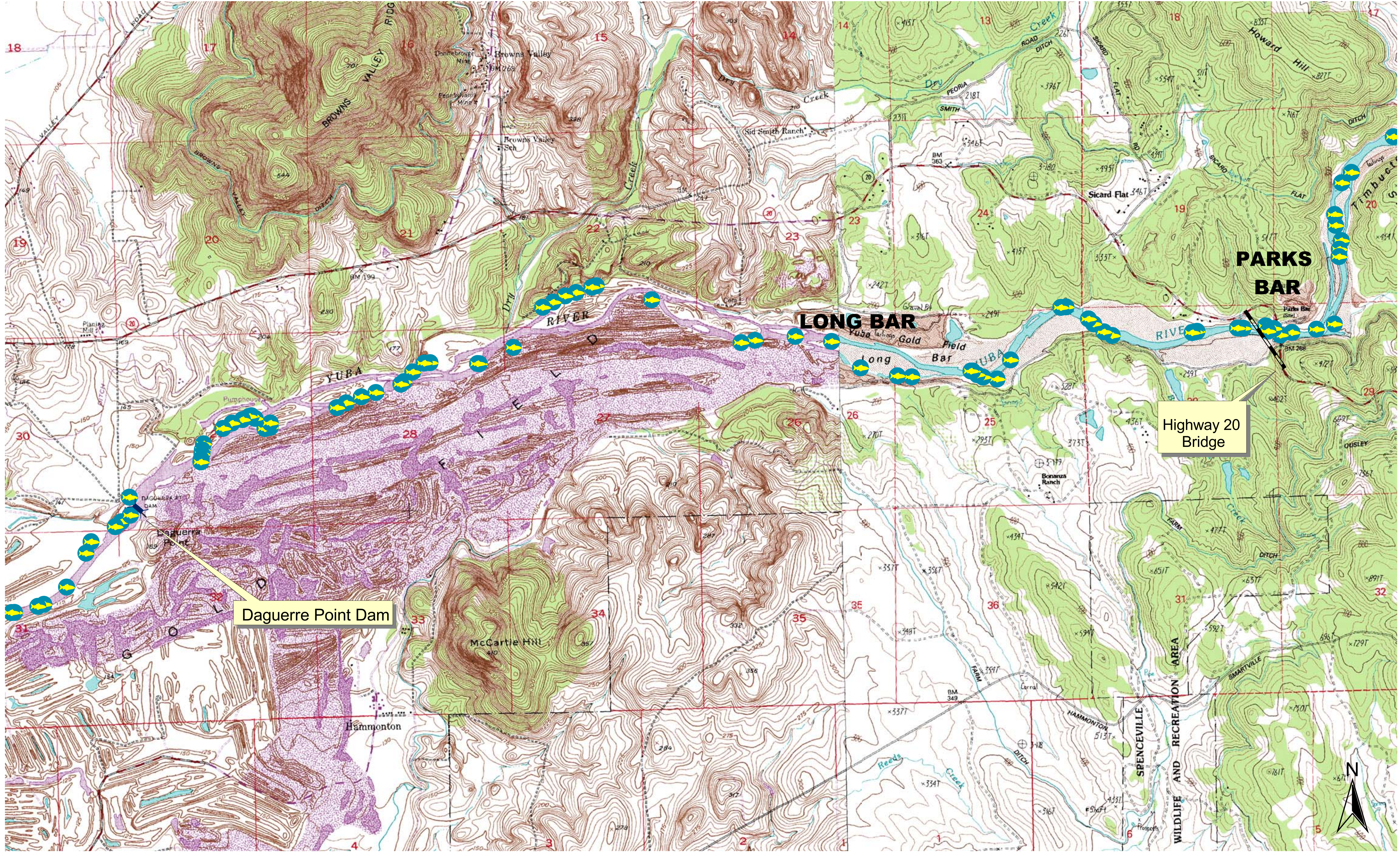
LOCATION USFWS 2001 SPRING-RUN CHINOOK SALMON REDD SURVEYS - ROSE BAR REACH



LOCATION USFWS 2001 SPRING-RUN CHINOOK SALMON REDD SURVEYS - PARKS BAR REACH

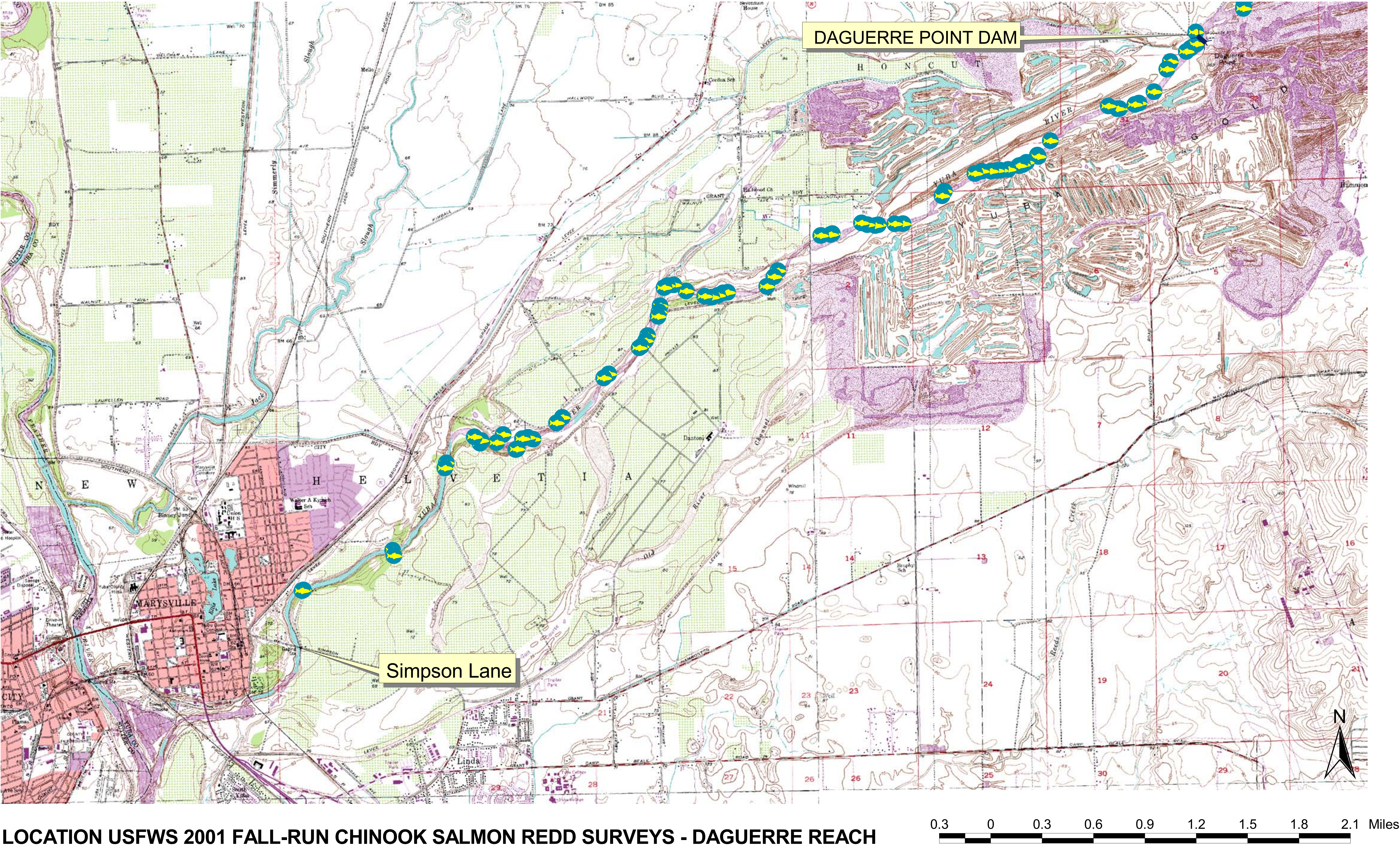


LOCATION USFWS 2001 FALL-RUN CHINOOK SALMON REDD SURVEYS - ROSE BAR REACH



LOCATION USFWS 2001 FALL-RUN CHINOOK SALMON REDD SURVEYS - PARKS BAR REACH

0.2 0 0.2 0.4 0.6 0.8 1 Miles



LOCATION USFWS 2001 FALL-RUN CHINOOK SALMON REDD SURVEYS - DAGUERRE REACH